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DESIGN OF A KNOWLEDGE MANAGEMENT MODEL FOR A SWINE SUPPLY CHAIN IN THE COLOMBIAN ANDEAN AREA USING THE BALANCED SCORECARD TOOL

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ACCEPTANCE NOTE

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ABSTRACT

Currently, swine production in Colombia is done mostly in rural areas, the swine supply chain (SSC) is the second in importance in Colombia's livestock sector but is characterized by being a very informal sector and its production is aimed at domestic consumption. Colombia imports approximately $ 221 Million US dollars per year in swine or some of its derivatives from countries such as the United States, Canada and Chile, among others. This research seeks to encourage productivity through the design of knowledge management strategies through the Balanced Scorecard (BSC), the methodology is developed by searching the literature for knowledge management indicators, among others, that apply or can be adapted to the SSC of breeding and fattening, Interviews will be built which will be applied to SSC participants to filter the key management indicators, characterize them and define the thresholds or standard, maximum and minimum values of these indicators. A Supply Chain Balanced Scorecard (SCBSC) will be built to monitor and measure the defined indicators and document best practices or strategies carried out by producers to improve indicators. This will allow the creation of a knowledge management model so that small and medium producers can gather information, store it and process it for decision making, It also seeks to design the bases so that in the medium term an information system can be developed to automate the SCBSC.

Key Words: knowledge management, Supply chain, Balanced Scorecard, Swine

1. INTRODUCTION

Swine meat production in Colombia is growing, the cumulative swine benefit in the last trimester compared to last year grew 9.3%. Most of the benefit contribution came from the departments of Antioquia (45,2%), Bogotá D.C. (16,3%), Valle (15%) and Meta (6,9%). The department of Cundinamarca was in one of the last places (0,5%) [1].

However, the Andean region of the country (Cundinamarca) presented a relative diminution in the swine benefit (-9,9%) due to factors such as a lower production by swine breeders. Migration of clients to another sectors, buying to third parties and in some cases closure of activity by some swine breeders [2].

The per capita consume of meat per-capita incremented in 1% respect the previous year reaching 9.3%, worldwide the production of swine meat from Colombia reached 0,4% [2]. It is evidenced that the swine production in Colombia is not enough to satisfy the internal demand which makes the country import pigs, swine meat and derived products from The United States of America, Canada and Chile [3].

In contrast to the agricultural activities the costs of the swine industry are marked by efficiency and can be improved trough better productive parameters. Elevating the production standard will allow the Colombian swine breeders to offer animals of higher weight and meat, which translates to higher economic benefits [2].

With the goal of helping the swine breeding sector to incentive its productivity this research project is focused on designing knowledge managing strategies for a swine supply chain in the Colombian Andean region using the Balanced Scorecard Tool. Because of this we worked on performing a literary review in order to identify the key indicators on knowledge management applicable to the swine industry, characterizing them and defining their standard values or measuring thresholds.

The actors in the swine breeding and fattening supply chain of the Andean region or Cundinamarca were identified, polls were designed and applied in order to share the proposed key knowledge management indicators and the opinion of the actors on the proposed indicators. This helped filter and focus on the indicators which the actors considered important and within the swine supply chain (SSC) in order to construct a Supply Chain Balanced Scorecard (SCBSC) that allows to track and control the indicators.

Lastly, the best practices and recommendations within a knowledge managing model were documented in order to allow the actors of the swine breeding and fattening SSC to take actions in those indicators that presented variations.

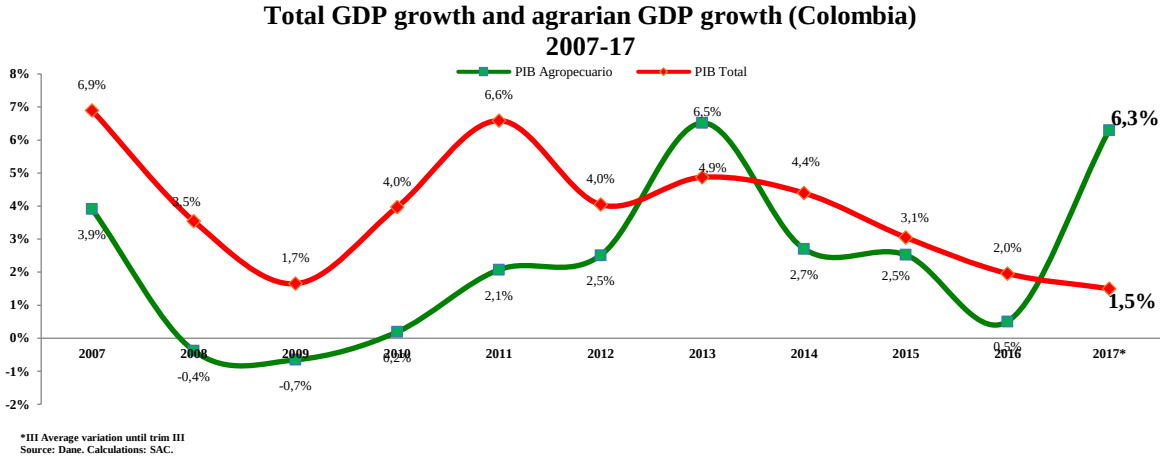
This research project was developed as a phase of the macro project called: Knowledge management model to rise competitiveness of the swine supply chain (SCC), leaded by the Center of Research in manufacturing and services of the Colombian School of Engineering (Category B), and the group “development and integral managing of projects” – Colombian school of Engineering. Additionally, this project also counts with the participation of the research group called Company management & innovation management of the Catholic University of Colombia (category A) and the research group “Interdisciplinary group of research for business sustainability and competitiveness – UNICAFAM” (Category C).

2. STATEMENT OF THE PROBLEM

2.1 PROBLEM

The second trimester of 2018 the gross domestic product (GDP) of Colombia grew 2.8% in respect to the same period in 2017 [4], observed an annually during 2017 this growth was 1,8%, leaded by the agrarian and financial services sectors. Currently, the agrarian GDP is 6.5% [5, 6] (see figure 1), besting on 2018 the global mean of 3.5% [7].

Figure 1. Colombian Total GDP Growth vs Colombian Agrarian GDP growth

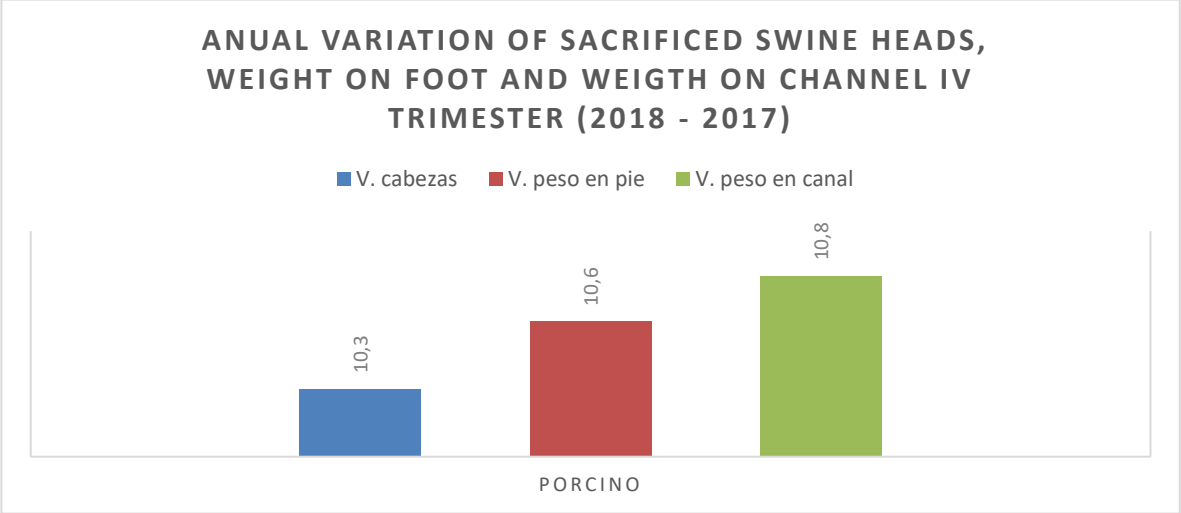


Source [6].

Colombia has a rural sector extended along its territory, historically, this sector has allowed the evolution of the country's economy, which allowed the accumulation of enough wealth to develop other sectors considered modern or urban, as technology and services. The main activity of the rural sector is the agricultural activity, subdivided in agrarian activity and cattle raising, this last one being composed of the bovine, swine and avian sectors among others [8].

During the October – December trimester of 2018 the swine sacrifice (1.256.812 heads) grew 10,3% compared to the same trimester of the immediate previous year. The female sacrifice count grew 10,8% and the male one 10,0% (see figure 2). During this trimester (October – December 2018) no sacrifice destined for exportation was registered [9].

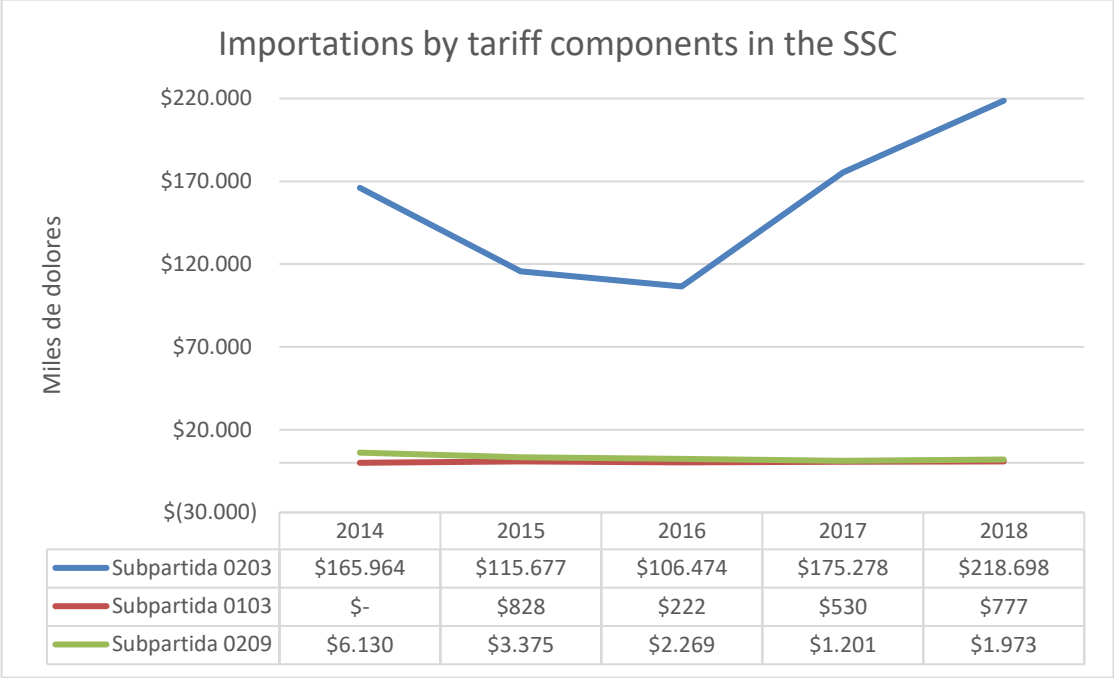
Figure 2. Swine cattle head sacrifices



According to data consolidated by the Colombian association of swine breeders PorkColombia, the year 2018 finished with a record number in the swine benefit, presenting a growth of 7% in respect to 2017. This obeys increments in the main plants of the Antioquia, meta, Risaralda, Atlántico and Quindío departments [10]. The home domestic production of swine meat in Colombia is not focused towards exportation, it is in contrast directed mainly to supply the internal demand [11]; the three principal importing departments are Bogotá, Valle and Bolivar. Currently, there is no evidence that they count indicators supporting or controlling said production.

The importations of the SSC have three components relevant to the Colombian economy: 0103 – Pure race reproduction swine, 0203 – Fresh animal meat of the swine species, refrigerated or frozen, and 0209 – Meat and consumable pieces; for 2018, the sum of this components was $221.448 thousand of American dollars (see figure 3). There is an increasing demand of channel meat importation since 2008 until the present. The countries from which those operations are performed are the United States of America (comprising 93% of the market), Canada (4%), Chile (3%) And other countries like Denmark, Portugal and Spain 0.1% [3].

Figure 3. Tariff components important for the SSC – Importations in Colombia

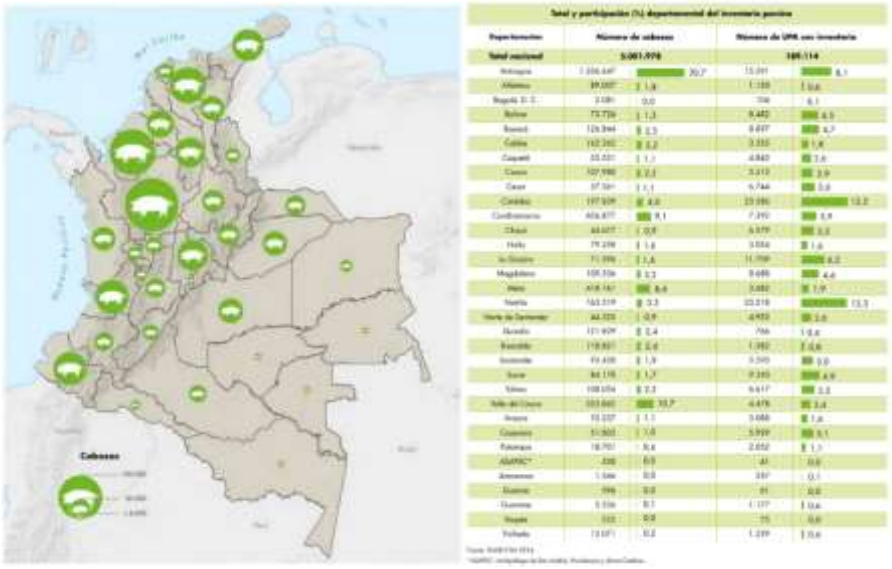


	2014	2015	2016	2017	2018
Subpartida 0203	$165.964	$115.677	$106.474	$175.278	$218.698
Subpartida 0103	$-	$828	$222	$530	$777
Subpartida 0209	$6.130	$3.375	$2.269	$1.201	$1.973

The free commerce treaties signed with other countries that are important swine meat exporters like the united states of America have put in disadvantage the Colombian swine breeding sector, because these treaties were negotiated in terms that did not acknowledge the level of development of the domestic product. Currently the tariffs for swine meat importing from the USA and Canada are zero Colombian pesos ($ 0.00 COP), however the required inputs for swine breeding in Colombia, like corn, must pay importing tariffs [12].

The swine SSC in Colombia is the second most important in cattle raising, representing around 17% of the national production [13]. The third and last national agrarian and cattle raising census of the National Administrative Department of Statistics (DANE) had an operative coverage of 98.9 %, reaching 1.101 municipalities [14], encompassing enclosed swine facilities with roof, independent access and separation of species. The swine inventory was conformed by reproductive males, gestating female swines, lactating and non-lactating swines, replace swines, domestic farm swines and fattening swines. Most of the swine cattle is located in Antioquia, Valle del Cauca, Cundimarca, Meta and Córdoba (see figure 4) [13].

Figure 4. Distribution (%) of the national swine inventory, according to DANE vs UPA (Agrarian and cattle raising producing units).



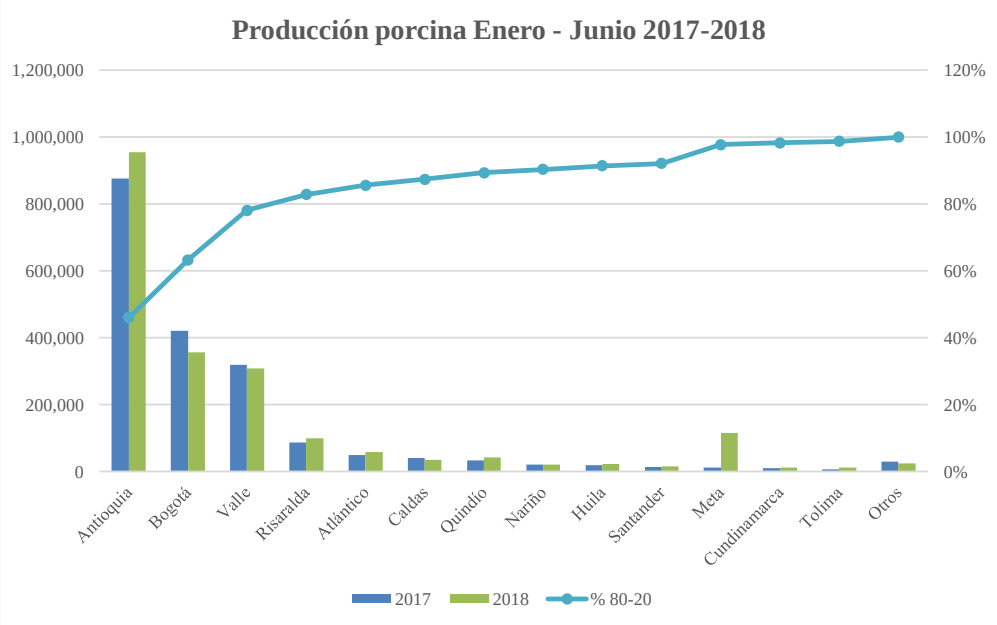
Source. [13]

Natural and juridical people, along with commercializes must pay and deposit a tariff to the national fund of swine cattle raising (CFP – *Spanish: Cuota de fomento porcícola*), which equates to 32% of a current legal daily minimum wage [15]. Most of this tariff is given by Antioquia, Bogotá. Valle del Cauca, Meta and Risaralda [16].

The collection of the CFP indicates the amount of swine sacrifices on the national level; if the medium weight of a pig is 111 kg for the year 2018 458 thousand tons were sacrificed [17]. For the second trimester of 2018 a register of 1.075.697 sacrificed heads was received. Showing an increment of 1.057.697 sacrificed heads of swine cattle, showing an increment of 9% compared to the same period of 2018 [17].

According to [18] information the Meta department has increased the amount of swine sacrifices, reaching 956.3% the amount of the first semester of 2017 and 2018, reaching a production of 115.852 swine heads, positioning itself as the fourth productor on a national level in 2018 (see figure 5).

Figure 5. Production 2017-2018 by departments.



Even though the swine meat production in Colombia has been improving, we still must design and develop instruments and tools that allows us to improve the whole swine supply chain (SSC) in Colombia.

Currently, companies look to identify, follow and control their processes with the goal of guaranteeing the compliance of the client service accords, improve productivity and satisfy the strategic planning [19].

The form of measurement is not new, at the end of the previous century, Lord Kelvin (William Thomson, British physicist and mathematician) said: I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind".

In 1987 the Massachusetts Institute of Technology (MIT) productivity commission, after examining eight production sectors, recommended the industrial sectors to create techniques ideal to measure and improve the efficacy in the production [20]. In 1989 Harvard University suggested to create a framework to measure company actions based in indicators centered in clients and their expectations [20].

In the 90s decade, Kaplan and Norton defined a measurement system called the frame of integral command or Balanced Scorecard (BSC), which divides de company's objectives in 4 main perspectives: Financial, client, internal processes and formation & growth. This tool allowed companies to manage their strategies on

the long-term trough management indicators that measure the attainment of goals, which need design and implementation of strategies to fulfill term successfully [21].

The progressive transformation and evolution of the swine sector, towards more complex and technical systems, has caused that the data management of the supply chain be fundamental to achieve a high level of information. Alongside this, the information management represents a continual improvement process of incrementing productivity and promoting the mid-term association of small and middle size swine productors, allowing them to participate in a competitive manner in the market, guaranteeing sustainability and presence on a local, regional and national level, with goal of becoming competitive in the international market in the future [22].

2.2 RESEARCH QUESTION

Can a model of knowledge management oriented to the construction of a balanced scorecard incentivize the improvement of the management indicators for the SSC in the Andean region of Colombia?

2.3 JUSTIFICATION

Many milestones converge in Colombia for the rise of productivity. Since 1994 different programs for the promotion of clusters in Colombia have been developed; The first was made by the company Monitor Group, which studied the competitivity under Michael porter´s diamond model [23]. In this study the conclusion was that although Colombia had many natural resources, there were still failures in terms of competitivity [24]. This study allowed the creation of the Competitivity National Council (CNC) in 1994 as well as the establishment of the National Strategy of Competitivity in 1996; later, sectorial accords of competitivity (SAC) were subscribed by the productive chains [25]. Some of the first SAC subscribed directed towards agricultural chains were for the aviculture, porciculture and aquaculture sectors [26].

In 1999 the National Policy of Productivity and competitivity (NPPC) was proposed, which is a strategy for the impulse of the economy maintained through time, this allows the interactions of the actors during the productive process [27] and supports the supply chains in order to rise the global competitivity [28]. With the NPPC, the Internal Agenda for Productivity and Competitivity (IAPC) was created between 2004 and 20017 with the goal of providing tools to the regions for competing in an international context. Initially, the IAPC proposed 20 agendas for the agroindustry sector, among these, to articulate the production of meat products by regions [25], which applies to the SSC.

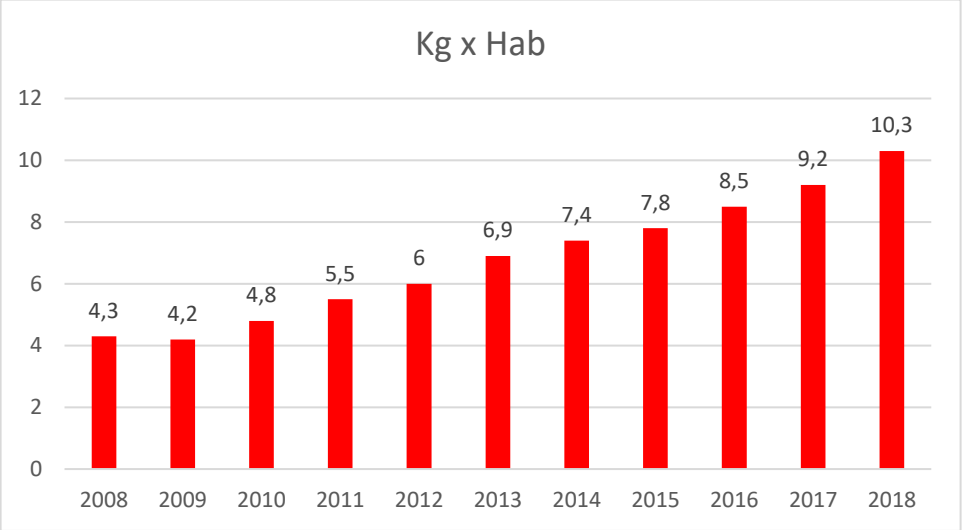
On September 16th, 2010, the National Accord of Competitivity (NAC) for the SSC was signed, determining aspects of the research for competitivity in terms of innocuity, production, marketing and transformation, among others. Additionally, on the resolution 00126 of May 9th, 2011, the SSC was recognized by the Ministry of agriculture and rural development [29].

On 2012, the strategy of BANCOLDEX (Bank of external commerce) called INNpulsa was created to promote entrepreneurship, innovation and productivity in Colombia; receiving initiatives of clusters stablished as axis of corporate and competitive development [30]. To 2018, the strategy has fortified and pushed forward 58 clusters and 636 companies with transference of knowledge through the Colombian Cluster Web, an agreement generated among the Private council of Competitivity (PCC), BANCOLDEX and INNpulsa Colombia [25]. Currently the Colombian Cluster Web reunites systematically 88 initiatives of cluster [25], however, currently there is no agglomeration proposal for the SSC that allows its monitoring and improvement, nor knowledge generation; There have been many governmental, academic and trade collective initiatives for potentializing the SCC, but none has been consolidated.

In 2016, during the first trimester an international cooperation accord was signed between the country of Denmark and the Colombian Ministry of Agriculture and Rural Development, this accord was focused towards knowledge transference through consulting and assessment for a period of 2 years in regards to strategies to improve competitivity in the swine industry in topics such as residue control, pathogen control, risk analysis and critical aspects of inspection, vigilance and control (IVC), this accord began activities of its first phase in august 2016, the entities responsible for its execution were the Colombian Agriculture Institute and the National Institute for Medication and Food Vigilance (INVIMA; *Spanish: Instituto Nacional de Vigilancia de Medicamentos y Alimentos*). In 2018, the second phase of the accord started, continuing the topics defined in phase I [12].

The pork consumption in Colombia has been incremental the last 10 years according to statistics from the Cattle Raisers Federation (FEDEGAN); in 2018 the consumption was 10.3 kilos per inhabitant (See figure 6) [31].

Figure 6. Per-capita consume of swine meat in Colombia



Source: PorkColombia – F.N.P., DANE Economic area calculation

The porciculture sector is very attractive for the economy due to its capacity of job generation and economic development. However, its growth depends on research, innovation, development, productive cost reduction (which composes around 60-70 of the total cost), plague and outbreak prevention, healthcare quality and innocuity, as well as the lack of consideration for cattle raising politics (FAO) [32].

In the XXI century, knowledge management is done in order to allow people to provide their intellectual capacity and experiences in the direction of increasing the efficiency of the processes and the acceleration of the activities of their organization. However, the key still resides in the individual knowledge. It's the entities, institutions or governments who must give people enough guarantees for depositing knowledge to be motivating and gratifying.

The knowledge management (KM) has surfaced as a strategy that the entities need to adopt in order to manage and use the organizational knowledge. But, in order to respond better to the changing circumstances in which they live, the knowledge management itself has been made to evolve towards new tendencies [33].

Having this into account, this research pretends to design a methodology to follow the KM indicators in order to articulate a supply chain in the swine cattle breed and fattening, establishing the bases for the elaboration of a software that administers these issues with agility. This is a phase to incentivize this type of agglomeration to increase their competitivity in the SSC.

3. OBJECTIVES

3.1 GENERAL OBJECTIVE

To design a methodology for the knowledge management in the SSC based on a BSCSC for the swine cattle and fattening productors in the Andean region of Colombia.

3.2 SPECIFIC OBJETIVES

- To characterize the breeding and fattening processes and the group of current indicators for the knowledge management in the SSC.

- To prioritize the indicators for the construction of a SCBSC validating them with the actors of the SCC.

- To design a model of the theoretical knowledge management integrated with the BSCS for a breed to fattening phase of the SSC.

4. CONCEPTUAL FRAMEWORK

An indicator is defined as a proposition that identifies an empirically observable feature or characteristic that allows the statistical measure of a concept or a dimension of it, basing itself in a previous theorical analysis, integrated in coherent system of linked propositions, which analysis can be oriented to describe, compare, explain or foresee real successes [34]. The indicators are key or vital variables, for which there are goal thresholds or values to reach. They are also considered to be observation and monitoring instruments [35]. This is how in this research the key indicators or variables will be identified within the breeding and fattening steps in the SSC.

The management indicator allow the measure and analysis of the processes results, facilitating their agile analysis in decision-making [36]. This is how the management indicators will be used to construct a board of control within a model of knowledge management to articulate the swine supply chain in fattening and breeding.

The control board is a tool that allows to integrate the strategic planning and the evaluation of a company. It is a systematic organization of the information from the management indicators, destined to ease the decision-making process within a company. More structured than a group of indicators that inform the state of the more relevant aspects of a company. This tool is structured with the objective of showing a summary and state of the controlled activities [37]. A control board works as base for the construction of a model of knowledge management that allows the articulation of the swine supply chain in fattening and breeding.

Knowledge management, according to Keith Bradley is “the management and mobilization of untouchable actives of a company, over which the continual learning and improving capacity of an organization must be based” [38]. For Annie Brooking “the knowledge management contains the identification and analysis of knowledge, either available or required, along with the planning and control of actions to develop knowledge actives, with the goal of reaching the company’s objectives, which basically implies the development of strategic management [39]. The implementation of a knowledge management methodology based on management indicators will ease the articulation of the SCC, helping the development of strategic planning.

The supply chain is known as the group of companies integrated by providers, fabricators, distributors and sellers, which maintain efficient models or means of collaboration among them [40]. In this research we look to articulate the SCC through a knowledge management methodology based on the Balanced Scorecard.

For Norton and Kaplan, the frame of integral command (FIC) complements the traditional performance indicators, generally related to the past actuations,

aggregating performance indicators related to the future of the organization. This is a structure to transform a strategy in operative terms [41].

The Balanced Scorecard is a management tool defined as a planning and management system that allows the company to clear its vision and define strategies while they are being translated into actions [42-44].

The porciculture is the activity that includes the breeding, feeding and commercialization of pigs [45].

Trough the definition of key indicators and their constant measure the construction of a frame of command based on the Balanced Scorecard is achieved, allowing the integration of the SCC to measure deviations and in this way be able to take actions to improve and build a base for knowledge management in the swine fattening and breeding in the Andean region of Colombia.

5. THEORETICAL FRAMEWORK

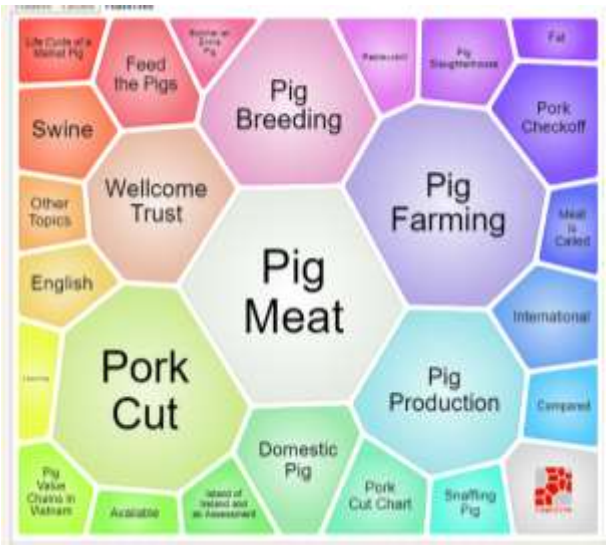
A research about knowledge management models in the swine industry was performed using the Scopus database, Google academic and the webpages related to the swine industry in Colombia.

For the search, the following keywords related to the research project were used:

- *Cerdo, Porcino* - pork, pig swine
- *Gestión del conocimiento* - knowledge management
- *Indicador* - indicator
- *Cuadro de mando, tablero de control* – control panel, Balanced Scorecard
- *Mejora continua* - continuous improvement

A search for the keywords was performed on search.carrot2 and the following graphic results were obtained:

Figure 7. Concentration of keywords – Analysis performed on search.carrot2



Figures elaborated with the webpage of search.carrot2

The words related to food, virus, medicine, health, etc. must be filtered, leaving only the ones that refer to production or processes.

Se procedió a realizar la consulta de artículos en las bases de datos Scopus, donde se ejecutó la búsqueda teniendo en cuenta las siguientes formulas:

Chart 1: Search formula for knowledge management in the Scopus database.

Formula
(“knowledge management” OR indicator) AND (pork OR swine OR pig)
(("knowledge management" OR indicator) AND (pork OR swine OR pig)) AND (LIMIT-TO (SUBJAREA , "AGRI")) AND (LIMIT-TO (SRCTYPE , "j")).
“knowledge management” AND (pork OR swine OR pig)
("supply chain”) AND (pork OR swine OR pig)

The inquiries were filtered removing or eliminating the articles referring to topics such as medicine, health, genetics, food and virus. Focusing the search on topics related with agriculture with a special emphasis in the cattle production and/or the porcine subsector, finding a good number of related articles in a worldwide level for our research.

Globally, the food industry is exposed to globalization and robust supply chains that include a variety of products, quality and safety. It’s because of this that food industries must comply with strict sanitary measures and some big companies have adopted within their supply chains their own standards, including environmental,

social, labor, and animal safety topics, among others. Because of this, it is said that today more than ever, the food supply chains need to implement or reorganize information systems that integrate the actors in all the supply chain [46]. According to Zhang Ke “there is a great breach among the operation of the supply chain and the cattle industry. The porcine products are not competitive in the international market “ [47].

The coordination among organization of a product supply chain allows to satisfy the needs of the consumers. In order to achieve this, there are various mechanisms such as product standards, quality management systems, integrator chains, information systems, etc. However, introducing the costs of coordination among companies makes the communication and decision-making process heavier. The companies tend to minimize this cost applying processes or operations standards as well as knowledge and skills standards, the last one through the education of the people executing the process, generating results supported in technology to manage the needs of communication or the processing of information [48].

In the search of company excellence many organizations understand that the human capital is a resource that can be valued, developed and measured just as any other resource, making the human knowledge a competitive advantage for the companies. Considering that organizations cannot create knowledge by themselves, they depend on the human capital for this task. That is how is described by Elisângela Freitas da Silva, “it is through the domination of internal knowledge that the companies remain safe and operating, with the adoption and even the advent of movements such as spontaneous exit or motivated by employees, key knowledge of the people, corporate training, company environment following and management of the supply chain [49].

Different projects have been developed worldwide with the purpose of improving the SCC by intervening in the human capital, knowledge management and information systems.

In the People´s Republic of China, a solid security system was constructed to produce high-quality swine meat, guaranteeing three aspects within the supply chain: standards, production and follow-up. The traceability system was the major issue; thus, they constructed an information system to control the complete traceability and link the whole supply chain. The system is applied from advanced technologies like dynamic control, unified coding, radiofrequency, bus communications and logistics engineering [47].

In the Netherlands, third pork meat exporter of the EU (European union), a project of coordination among two Swine Supply Chain was made, where a central agent reunites and combines all the chain, as well as the information to manage the

fulfillment of the quality held by the country. The chain of fresh meat, a chain with a possibly high baseline quality level and a wide broadband, with process and exit of standardization, knowledge, skill and flow of information from link to link and smaller chains, like the biologic chain or regional chains, with quality high level of wide and narrow broadband along with coordination by hierarchy and mutual adjustment [48].

In Latin America there have been various initiatives to increase knowledge through research and development promoting animal well-being and meat-quality. These initiatives have given good results, but there has been an increase in the demand for personnel with better formation in the application of concepts such as animal well-being and management of cattle in the meat supply chain. In order to attend this demand is necessary to maintain an efficient system of knowledge transference to all parts interested in meat supply chains in Latin America [50]. On a regional level it is evidenced that countries like Uruguay perform studies to improve their porcine production with the vision of becoming importers. Their studies involve analysis of the in international market, swine supply chain, technological aspects and competitiveness, comparing themselves with countries such as Chile, Brazil and Argentina [51].

In México, the operative coordination of the Mexican Institute of Transportation, makes an analysis of the value chains and the SCC, proposing improvements in the transport logistics like the integration of transport in the SCC and the measurement of the performance through the development of indicators of the supply chain, as well as the implementation of a Scorecard or an Integral Command Control (ICC) and defines a framework for the homologation of performance indicators in the supply chain [52].

Chile in 2017 produced 490 tons of stick and 59% was destined to exportation, the per-capita consume was 18 kg per person. Their exportations are mainly to the Asian market, which represents 71% of exportations, Japan conforming 25%, South Korea 25% and the People's Republic of China 21%. The porcine industry can export to 64 countries worldwide [53]. Chile in their latest years has industrialized the swine production and has improved their intensive productive system, transforming the production in a high level of supplies and elevated performance, being competitive for their high productive indexes. In consequence of the good development of the private sector in coordination with the government, improving control programs along with disease prevention and food innocuity [54].

Brazil is one of the biggest pork productor in Latin America, with great presence as exporter occupying the first steps on a global scale. The swine productive industry of Brazil is historically the most advanced in the region and continues to stand out globally because of their high levels of productivity, due to the elevated incorporation of technology in all of their productive areas, including handling, nutrition, healthcare, genetical improving and vertical integration. The integration is fundamental for the permanence and productivity of many sectors and has allowed Brazil to position itself

as one of the major exporters of pork [55]. One of the projects implemented in 2016 was based in a model of Von Krogh et al. (2001) to identify and analyze how the instructors are present in the creation of organizational knowledge- This project was implemented in the farm of swine culture DF Pork, located in the municipality of Faria Lemos, in Minas Gerais (Brazil) [49].

In Colombia, a series of isolated and individual projects gave been developed, oriented towards improving or supporting the SSC, such as:

- Master's degree thesis: Plaza Colombia: Model of business for the creation of competitive advantages using information technologies in the agricultural sector [56].
- Graduation project: Design and implementation of an application for mobile devices that allows the automatization of a system for the supply of swine food under the Android platform [57].
- Research group – Biogestion of the National University of Colombia: Seeding innovation for the competitivity of the agrarian and cattle sector of Colombia [58].
- Colombian Ministry of Agriculture and rural development: Agenda for research and technological development for a swine meat chain [59].

By performing a review of the market, we found a variety of systems that measure indicators and carry statistics focusing in the productive and financial sector, but don't make emphasis in knowledge management and important factors such as human capital, environmental management, social management, etc.

Chart 2: Support software for the SSC found in the market.

Platform Name	**Country**	**Objective**				**Observations**	**source**
		C	S	T	AP		
3tres3.com	Spain	x	x	x	x	3tres3.com is a webpage that shares information about actuality, healthcare, economy, nutrition, genetics, reproduction, handling, installations, articles and software related to the SSC.	[60]
Porcitec	Spain	x	x		x	Porcitec is a program of porcine management that helps optimize the performance of your farm and increase its productivity. Porcitec gives tools for the decision-making process through a fast data input, a simple but efficient	[61]

Platform Name	Country	Objective				Observations	source
		C	S	T	AP		
						method for reports. Available for web browsers, desktop and mobile.	
Porci control	Spain	x	x		x	Porci Control has been developed in collaboration with cattle ranchers and veterinarians of the sector with the goal of cover all de needs of porcine exploitation in one program.	[62]
Pigchamp	Spain	x	x	x	x	Services of fata management and productivity analysis, project management, research, development, applied research and improvement of productivity.	[63]
Criaderos Online	Argentina	x	x	x	x	The application allows your employees to store data in a fast and simple way in their mobile device in order to manage it from a web system, without need of physical presence in the breeding grounds, production, rentability or females.	[64]
Incontrol porcinos	Spain	x		x	x	InControl swines allows the administration of a farm with success, saving costs, procedures and facilitating everything related to the animal life: Care, growth, life quality, fattening, sell, visits to the veterinarian… the result?, time saved and money for the rancher, along with the maximum efficiency in management.	[65]
Infopork	Argentina	x	x	x	x	The development of this program surfaces as an answer to the need of a reliable storage system for all registers of productivity of swine exploitation, which allows to stablish reproductive and productive controls through data analysis.	[66]
Suinoweb s	Colombia	x	x		x	Manages your animal file, registers for 45 data entries, 58 orderable and graphicable lists, personalized lists, control graphics, 21 population informs, breeding, milk production, meat	[67]

Platform Name	Country	Objective				Observations	source
		C	S	T	AP		
						production, economy and market. analysis and planning of farms.	
Softporc	Colombia	x	x		x	Software for the management of information in swine farms that count with site 2 and/or 3, pre-feeding and feeding. Eases information analysis from an economical technical viewpoint.	[68]
Pigwin	USA	x	x		X		[69]
Zooeasy	USA	x	x		x		[70]
BCS sowdition	Germany		x		x	APP de la empresa Bayer que ayuda a través de las medidas y pesos a conocer el estado de los cerdos Bayer company application that helps to know the state of the pigs through measurement and weight taking.	[71]

C: Creation; **S:** Storage; **T**: Transference; **AP**: Appropriation.

5.1 LEGAL FRAMEWORK

5.1.1 Regulating entities

In Colombia there are diverse regulatory entities for the SCC, which must see that the actors comply with the current regulations during their economic activities.

Chart 3: Competent authorities to regulate the SCC.

ACTIVITY	Competent authority
Primary production (farms, ranches)	Colombian agricultural and cattle institute.
On-foot animal transport	Colombian agricultural and cattle institute. Ministry of Transportation
Benefit plants	INVIMA
Lay-off plants	INVIMA
Meat derivates plants	INVIMA

ACTIVITY	Competent authority
Meat transportation, consumable meat products and meat derivates	Territorial health Company
Distribution and commercialization	Territorial Health Company

Source: [72]

5.1.2 Applicable normativity

Considering the big environmental impact of porciculture and because of being a product for human consumption, the most relevant normativity is mentioned:

Chart 4: Colombian normativity applicable to the SCC.

HYDRIC SOURCES	
Law 373 of 1997	By which the program for water saving and efficient use is stablished.
Decree 3100 of 2003	Regulates the retributive tariffs for the use of water as receptor of industrial waste along with other dispositions. Modified by the decree 3440 of 2004.
Decree 1575 of 2007	Stablishes the system for protection and control of water for human consumption.
Decree 1541 of 1978	Classifies bodies of water according to wastes poured.
Decree 4741 of 1995	Regulates the prevention and management of dangerous residues generated within the frame of integral management.

WATER AND HYDRIC RESOURCES MANAGEMENT	
Resolution 02499 of 1979	Stablishes the concession, control of training and permits for water exploitation as well as management of subterranean waters and pouring of residual waters.
Decree 2857 of 1981	Regulates part XIII, title 2, chapter II of the decree 2811 pf 1974 about watersheds and basins, among other dispositions.

WATER AND HYDRIC RESOURCES MANAGEMENT	
Decree 1594 of 1984	Regulates the title I of the law 9 of 1979 as well as the chapter II of the title VI, part III, book II and the title III, part III, book I of the decree-law 2811 of 1974 concerning uses of water and liquid wastes.
Law 373 of 1997	Stablishes the program of efficient water use and saving.
Decree 475 of 1998	Stablishes technical norms for the quality of potable water.
Decree 321 of 1999	Adopts the national plan for contingency against oil spills, derivates and damaging substances in sea, river and lake water.

WASTEWATER MANAGEMENT	
Dec. 1594/84 Art. 86,90 y 98	Sufficient capacity of pipeline (diameter) of evacuation for residue water from the animal benefit plant towards the drainage system.
Dec. 1541/78 Art. 200	
De. 1541/78 Art. 227	Water treatment system that reduces 80% of contaminant load.
Dec. 1594/84 Art. 72, 73, 84,86	
Dec. 2811/74 Art. 142	Residue water pouring permits.
Dec. 1541/78 Art. 211, 213	
Dec. 1594/84 Art. 98	
Res. 2905/07 Art. 7	
Decree 1594 of the 84 art. 160 y161	Residue water characterized by a laboratory accredited by the Colombian Institute of hydrology, meteorology and environmental studies.
Decree 901 of 1997 art 18	

ATMOSPHERIC EMISSIONS, NOISE GENERATION AND PARTICLED MATERIAL	
Decree 948/95	Regulates: Partially the law 23 of 1973, articles 33, 73,74,75 and 76 of the decree-law 2811 of 1974; The articles 41, 42, 43, 44, 45, 48 and 49 of the law 9 of 1970; and the law 99 of 1993, in relation to the prevention and control of atmospheric contamination and protection of the air quality.
Resolution 0058 of 2002	Establishes norms and maximum thresholds for the emission of incinerators and crematories of solid and liquid reside. Modified partially by the Res. 886 of 2004.
Resolution 601 of 2006	Establishes the norm of air quality for all the national territory in reference conditions.
Resolution 627 of 2006	Establishes the national norm for noise emission and environmental noise.

GB35:C42 AIR MANAGEMENT	
Decree 002 of 1982	Regulates partially title I of the law 9 of 1979 and the decree-law 2811 of 1974. Respecting the atmospheric emissions, current articles.
Decree 948 of 1995	Regulates partially the law 23 of 1973, articles 33, 73, 74, 75 and 76 of the decree-law 2811 of 1974; the articles 41, 42,43,44, 45, 48 and 49 of the law 9 of 1979; and the law 99 of 1993. In relation to the prevention and control of the atmospheric contamination as well as the protection of the air quality.
Resolution 898 of 1995	Regulates the environmental criteria of the liquid and solid fuel used in internal combustion engines of automotor vehicles.
Decree 2107 of 1995	Modifies partially the decree 948 of 1995 that contains the rules of protection and control of the air quality (norms about vehicular emissions).

GB35:C42 AIR MANAGEMENT	
Resolution 005 of 1996	Regulates the permissible levels of emission contaminants produced by mobile sources of gasoline and diesel, defines equipment and procedures of the emissions and adopts other dispositions.
Resolution 125 of 1996	Adds the resolution 898 of august 23 of 1995, which regulates liquid fuels in commercial use for internal combustion engines.
Resolution 909 of 1996	Modifies partially the resolution 005 of 196 which regulates the permissible levels of emission of contaminants produces by mobile terrestrial sources powered by gasoline or diesel, defines the equipment and procedures for measurement of said emissions. Also adopts other dispositions
Decree 1697 de 1997	Partially modify the decree 948 of 1995, containing the rules of protection and control of the air quality (aspects about fuels).
Resolution 627 of 2006	Stablishes the national norm of noise emission and environmental noise.
Resolution 0068 of 2001	Partially modifies the resolution 898 of 1995, added to the resolution 125 of 1996 and modified by the resolution 623 of 1998, which regulates the environmental criteria of liquid fuel used in combustion engines.
Resolution1351 of 1995	Adopts the declaration called state inform of the state of emissions.
Resolution 2308 of 1986	Adopts a procedure for analysis of the air quality.
Resolution 001792 of 1990	Adopts limit values permissible for the occupational exposure to noise.
Resolution 601 of 2006	Establishes the quality norm of the air for all the national territory in reference conditions.
Decree 979 of 2006	Modifies the articles 7, 10, 93, 94 and 108 of the decree 948 of 1995.

DANGEROUS RESIDUES	
Law 430 of 1998	Dictates prohibited norms in Ambiental issues relating the dangerous wastes and dictates other dispositions.

DANGEROUS RESIDUES	
Decree 4741 of 2005	Regulates partially the prevention and management of residues and dangerous wastes generated within the framework of integral management.
Resolution 1402 of 2006	Develops partially the decree 4741 of December 30 of 2005, in matter of residues or dangerous wastes.

SOLID AND DANGEROUS RESIDUES	
Decree 2676 of 2000	Regulates in environmental and sanitary terms the integral management of the hospital wastes and similar, generated by natural or juridic persons.
Decree 4741 of 2005	Regulates partially the prevention and management of residues or dangerous wastes generated in the framework of integral management.
Resolution 1402 of 2006	Develops partially the decree 4741 of December 30 of 2005, in matter of residues or dangerous wastes.

ENVIRONMENTAL TARIFFS	
Decree 3100 of 2003	Regulates the retributive tariffs for the direct use of water as receptor of pouring of waste and residue. Takes other determinations.
Decree 3100 of 2003	Modifies partially the decree 3100 of 2003.
Resolution 0273 of 1997	Fixes the minimal tariffs of the retributive taxes for the liquid waste pouring for the parameters of biochemical demand of oxygen and total suspended solids.
Resolution 0372 of 1998	Actualizes minimal retributive tariffs and maintains regional factor.

MANAGEMENT OF PESTICIDES AND DANGEROUS PRODUCTS	
Decree 775 of 1990	Use and management of pesticides.
Law 1843 of 1991	Partially regulates the titles III, V, VI, VII and XI of the law 9 of 1979 about the use of pesticides.

MANAGEMENT OF PESTICIDES AND DANGEROUS PRODUCTS	
Resolution 3079 of 1995	Dictates dispositions about the industry, commerce and applications of bio-inputs, fertilizer, fertilizers, amendments, soil conditioners, pesticides, physiological regulators, adjuvants of agricultural use and related products.
Law 430 of 1998	Dictates prohibitive norms in environmental matters related to dangerous waste.
Resolution 0058 of 2002	Establishes norms and maximum permissible limits of emission for incinerator and crematoriums of solid and liquid waste.
Resolution 0886 of 2004	Modifies partially the resolution 0058 of January 21 of 2002 and dictates other dispositions.
Decree 2811 of 1974	Establishes measures of personal protection in the use and management of pesticides.
Decision 436 of 1998	Andean norm for the register of chemical pesticides of agricultural use.
Resolution 0662 of 2003	The ministry of environment, housing and territorial development establishes the procedure for the expedition of the environmental dictamen that refers to the Andean norm for the register and control of pesticides of agricultural use.
Decree 1443 of 2004	Regulates partially the decree 2811 of 1974, the law 253 of 1996 and the law 430 of 1998 in relation to the prevention and control of environmental contamination for the use of pesticides and wastes or dangerous residues and takes other determinations.

SOIL MANAGEMENT	
Decree 2811 of 1974	Regulates the use, management and restoration of the soil.

VARIOUS DISPOSITIONS	
Regional and local accords	Environmental guidelines of different subsectors, punctual regulation.
National policy of cleaner production	Prevention and mitigation of the impact, increase of industrial efficiency, indicators.
Lineaments of environmental policy for the pesticide subsector	Prevention and minimization of impacts and risks; promotion of environmentally healthy and safe practices.

This normativity is based in the stipulated by the Ministry of Environment and Sustainable Development [72].

6. STATE OF THE ART

In order to begin to document this work we proceeded to perform a search of related articles with the following keywords:

- Cerdo, Porcino - pork, pig, swine
- Gestion del conocimiento - knowledge management
- Cuadro de mando, Balanced Scorecard

Then a consult of articles in the databases Scorpus and Science Direct was perform, executing the search having into account the following formulas:

Chart 5: Formulas for search of SSC articles.

Search formulas
"Knowledge" AND "Balanced Scorecard" AND "cattle raising"
"Knowledge" AND "Balanced Scorecard" AND "swine OR pig OR pork"
"Balanced Scorecard" AND "cattle raising"
"Balanced scorecard" AND ("pork OR pig OR hog")
"Balanced Scorecard" AND Agroindustry
"Balanced Scorecard" AND Colombia
"Balanced Scorecard" AND Colombia
"Balanced Scorecard" AND pork
"Balanced Scorecard" AND Swine
"cuadro de mando" AND agroindustria
"cuadro de mando" AND cerdos
"cuadro de mando" AND ganadería
"Cuadro de mando" AND Colombia
"Gestión del conocimiento" AND Balanced Scorecard"
"Knowledge" AND "Balanced Scorecard"
"Knowledge" AND "Balanced Scorecard" AND "agriculture"
"Knowledge" AND "Balanced Scorecard" AND "swine"
Balanced Scorecard

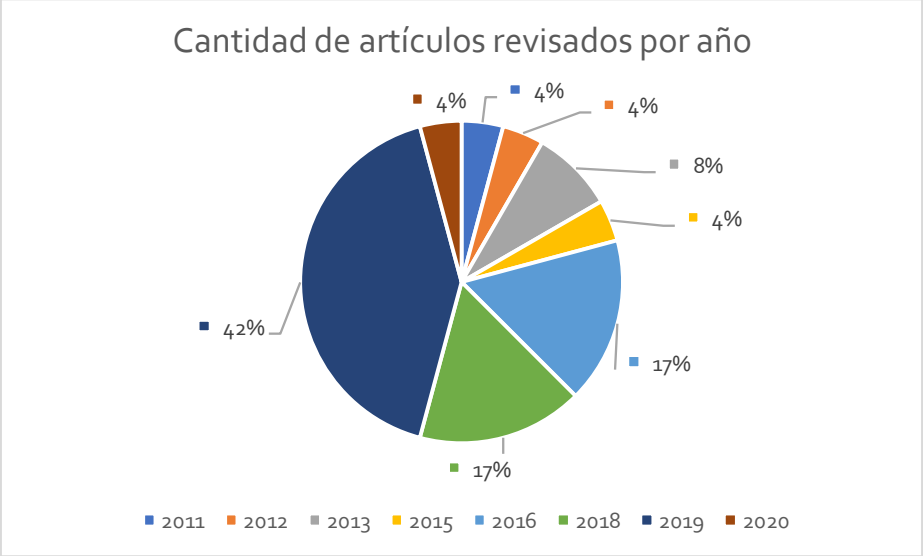
The searches were filtered by removing or eliminating the articles referring to topics related to medicine, health, genetics, food and virus. Focusing the search in topics related to agriculture and a special emphasis in cattle production and/or porcine subsector, it is evidenced that the material or related articles with this topics re almost

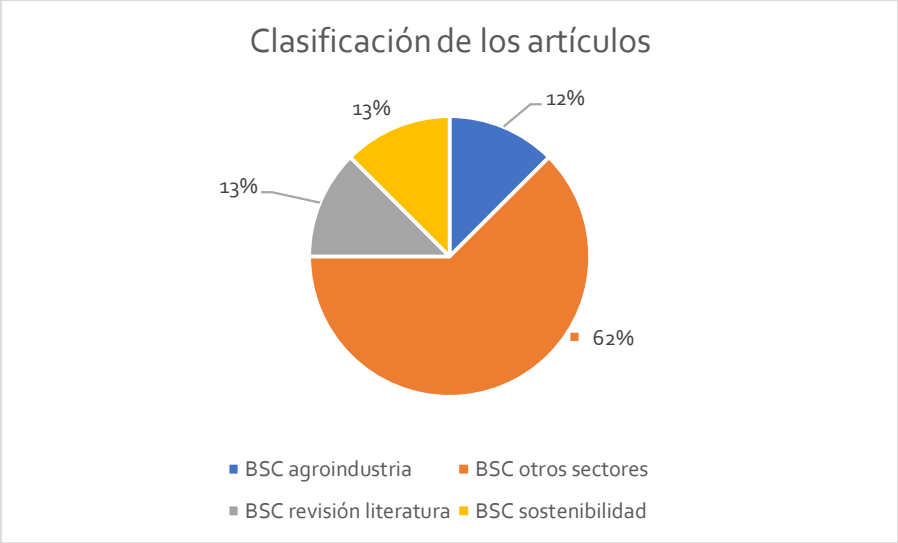
none, for this motive we focused the search of articles related with processes or production, finding articles where it was evidenced that the BSC as management tool can help the knowledge and improve productive sectors.

For the selection of the articles filtered were applied for the years since 2010 until 2020, after this, 24 articles were selected, classifying them in two categories: a) BSC applied in other sectors; b) BSC in agroindustry and sustainability.

With the presented criteria, in the literature reviewed we observed applications of the BSC in the fields described. Of the observed time window, in 2019 there is a concentration of 42 of the reviewed literature. 62% of the application of the BSC is in other sectors and not in agroindustry (see figure 1).

Figure 8. Articles analyzed and their classification.





Source: The author

It can be said that the Balanced scorecard since its introduction to the organizational world in 1991, it is a very popular management tool known in the organizational world for its efficient in the development, control and management of the corporative strategy. This tool was designed in the USA and is widely used in western countries, it helps satisfy the needs of growth and development of the small and middle companies, allowing them to maintain alive in the market [73, 74], however their efficiency in emerging economies is unknown [73, 75, 76].

The Balance Scorecard is an organizational tool that serves to measure performance, eases decisions, long-term planning and helps the company to center itself on the objectives tat impact the performance and productivity [44, 73, 77]. It is focused in four interlinked perspectives that allow to identify causal relations between financial and non-financial aspects that help strengthen the knowledge management and innovation [76, 78-80]. For the implementation of a BSC a previous study of the culture, process and indicators must be performed in order to avoid failure [75, 81].

In Slovakia a study about the use of the BSC by the countries companies was performed, and although it is a popular tool, it is not widely implemented in companies, but those who implement a BSC conclude that it has important benefits in the orientation of the managers over clients and partners, as well as the improvement of relations with the parts related to the CORE of companies, additionally, it conducts towards the improvement of internal processes eliminating barriers between the planned strategy by the high managers and the implementation

of it. The study also concludes that only big companies are interested in implementing the BSC as strategic tool [44].

In Indonesia, the southeast district of Maluku uses the Balanced Scorecard to measure performance of the fishing industry. Additionally, they incorporated other three tools: 1) Predictor models of the stock by RMS to determine the capture maximum, 2) Aggregated value model of analysis for margin of benefit to calculate the net benefit by unit of fisherman and the level of benefit margins and 3) Sustained analysis by multidimensional scaling method (MSM) to calculate the sustainability level of the fishing companies in the district, which is measured by tridimensional aspects (ecological, social and economic). In this way the model AgroFishDSS (Decision support system) was developed, which was designed as a tool to analyze the factors that influence the decision-making process related to the management of the fishing supply chain. Model of prediction of existences, model of aggregated value and model of sustainability [82].

Also in Indonesia, the north of Sumatra proposed an auditing of performance based in the BSC, used as a tool for management in the governmental sector, this is achieved doing a variation in the financial perspective and clients, leaving the client perspective (inhabitants) on first line because the state is directed towards the benefit of its inhabitants and not its finances. The focus in the measure and performance can be modified and adjusted in order to be used to evaluate adequately the performance of public responsibility [83].

In the people's republic of China, the BSC was fusioned with the Analysis Network Process (ANP), generating a control of the suppliers that integrate the construction of the maintenance chains for the agricultural machines that work in the interregional operations of the country. The BSC is a system of performance measurement that not only focuses on the financial perspective, the indicators evaluated in the BSC are a clear supply for the ANP method, that allows to take decisions evaluating multiple criteria to select the service providers, applied to the agricultural field [78].

In Chile it was stablished that all management systems developed for the agricultural industry were only for the viticulture industry, however this was centered in the management of the supply chain. Because of this an integral system of tridimensional performance measurement (SMD3D) was developed, evaluating and measuring the performance of the business in three dimensions: sustainability (social, environmental and economic), temporal (daily activities and strategic perspective) and special (extended supply chain). This SMD3D was based on the BSC due to results showing a positive correlation with sustainability management systems, however there are few evidences of its implementation [76, 84].

6.1 BSC IN OTHER SECTORS

In 2012 Hoque makes a bibliographic review of the BSC between 2000 and 2012, where the advantages and disadvantages area analyzed, concluding that it is more than a performance measuring instrument, a tool to help strategic planning (Hoque and Kaplan 2012), then, Casas (2019) using the BSC developed a model of strategic planning to improve the competitivity of small and middle size companies [74].

Zeng (2013) performed a study to determine the difficulties of the western globalized companies to implement the BSC when they have operations in the People´s Republic of China, where there have been certain limitations due to religious topics (Confucianism), in this study they recommend to know the employees, educate them, build a corporative culture towards the BCS and adapt the BSC to the local environment [75]. Complementing this study (Oliveira 2019) makes a study where they analyze the existing burocracy in the decision making in the deseing and implementation of a BSC, the author concludes that BSC must follow the compromise of the employees in contrast to obedience [85].

Sectorial studies have been performed to measure the impact of the BSC use in organizations. In 2016 Lesáková determines that the BSC brings great benefits to companies, applying 290 big companies, measuring the use and level of knowledge of the BSC in Slovakia [44]. Complementing this study, in 2018 Al-Qubasi develops a study in 568 big companies from the oil and gas industry in United Arab Emirates (UAE), with the goal of showing that through the BSC knowledge management, corporate culture and operative efficiency can be managed. Al-Qubaisi concludes that the learning perspective and development creates knowledge, that is reflected in operative efficiency obtaining good financial results, id there is a well-defined company culture [86]. In 2019 Poh Ling Chonga developed a study with 202 companies in Malaysia to identify the determining relation between the BSC, innovation and globalization. Concluding that innovation and globalization are essential for small and middle size companies because they allow their competitivity and growth, due to promotion of innovation and performance evaluation [87].

Firstly, there are applications of the BSC to improve the knowledge management, culture or performance of the workforce, in 2015, Gibbon uses a BSC to determine the workers incentives, concluding that the BSC is not standard, depends on the culture and must be created under the proper company culture [88]. In 2018 Huang Hao-Chen, proposed an intellectual system based on knowledge starting from the BSC with the goal to improve the strategic planning and the decision-making process [73]. In 2019, Manville proposed a BSC to monitor the transference of knowledge, abilities and technology from universities towards small and middle size companies, and their impact in their performance [80].

In second place, there are applications of the BSC in healthcare. In 2018, Harvey applies a BSC to a radiology company in the USA to determine the quality and financial health through key performance indicators (KPI), in this study using few indicators was recommended in order to avoid distractions for the decision-making process [81]. For 2019 Moraga implemented a BSC and its strategic map in a quantitative and qualitative way using DEMATEL, searching to calculate the cause-effect between the objectives of a local company dedicated to fabricating orthopedic products [77].

On third place, an application of the BSC to education was found, Peris-Ortiz (2019), performed a study on the influence of the BSC implementation in the Latin-American private universities with the goal of increasing the quantity and quality of research, and innovation in those educative services, existing common indicators. A favorable development of the universities was confirmed after its implementation [89].

On fourth place, two productive applications were found. Loayza (2019) designed a BSC based on the Lean Thinking method to eliminate waste and reprocessing in the companies of textile fabrication of Peru [90] and Hu (2019) proposes a combined BSC with ANP for the decision making process and keeping providers, constructing a web of interregional services for maintaining agricultural machinery in the People's Republic of China [78].

On fifth place, a social and governmental application for the BSC was found, Muda (2018) performed a qualitative research for the government of the north of Sumatra (Indonesia), where a BSC was implemented to evaluate their client perspective (the people), because the goal of a governmental entity is not financial profit, but its community satisfaction, the performance was measured in financial and non-financial aspects [83].

Lastly, the decision-making process with the BSC tool has been potentiated by mixing it with advanced techniques for the decision-making process, in the year 2011 Chytass, Panagiotis proposes a methodology to develop a general BSC that applies to any company using diffuse cognitive maps with the goal of defining KPI; the diffuse logic added serves to relate them, quantify their impact in respect to others and adjust the objectives of the BSC [43]. In 2019, Leksono used a BSC hybrid with an Analytical Network Process (ANP) for the measurement of the performance of the medical attention supply chain in Indonesia, with sustainability aspects were included [91].

6.2 BSC IN AGRICULTURE AND SUSTAINABILITY

After the literature review 6 studies related to sustainable perspective and agriculture we found, thus, it is important to highlight the direct impact over the natural resources and the measure of sustainability.

Teniwut (2013) developed an information system using the BSC to support decision-making, with the goal of increasing fishing production in the southeast district of Maluku (Indonesia) using a BSC which includes a sustainability component due to the environmental impact on the natural fluvial resources [82]. Then, Kalender (2016) developed a study to include the sustainability perspective within the BSC, for which the author recommended three forms: 1) Using a BSC with sustainable orientation, 2) Including indicators for sustainability within a learning perspective or 3) Creating a fifth perspective (2016) within the BSC called sustainability [76]. In the same year, Valenzuela proposes a tridimensional performance information system. Using a BSC that incorporates the sustain ability component for the wine industry in Chile; the sustainability aspect is incorporated because the food and beverage consumer demand products with less environmental and social impact [84].

In 2019, Myung develops a study in South Korea that looks to mitigate economical and physical risks in the social, environmental and economic performance, including a measurement of climate change in the organizational environment through a BSC, providing qualitative, quantitative and carbon measurement indicators [79].

In 2019 Hristo made a study on Italian companies to develop a sustainable BSC in order to guarantee sustainability and economical success for companies [92]. However, specifically for this research, one of the major uses of the BSC has been the measuring of rentability, specifically in the porcine industry. In 2016 Kuncová uses a model of lineal regression to determine economic performance and industry size, using the data compiled of the BSC of companies dedicated to swine breeding located in the Czech republic, as entry variables they used the coefficients of the rentability indicators, work productivity and operative indicators [42].

6.3 KNOWLEDGE MANAGEMENT IN THE AGRARIAN INDUSTRY

The seven articles that apply specially for the Knowledge Management (GM) in the Swine Industry (SI) are, in their order of importance: [93] who develops a software for KM and vertical integration, validated in four companies in the SI, KOSAROM SA Pascani who fabricate porcine food in Romania, however is transversal for all steps of the SI [93], later [94] makes a flux design of knowledge in three agrarian industries polled, belonging to the SI, forming part of a cooperative system called AURORA, as a result a benefit in the knowledge exchange among them is observed [94] and finally [95] makes a study applied to a porcine farm called DF Pork Company in which our abilities are applied for the creation and management of organizational knowledge [95].

There are other applications in KM for the SI that focus of traceability, indicator design and supply chain design, for which [96] designs a traceability software for a SI production company in the People's republic of China [96], then [97] develops a methodology for traceability in the SI and peanut industry [97]. However, [98] in the Netherlands applied mechanisms of coordination for two SSC [98], and [99] designs plans and programs of education in animal well-being and quality for the SI in Brazil, Chile and Uruguay as tools of the KM [99]. As result of this review we found that the dimensions of the supply chain for the SI are: a) rentability that covers incomes and costs of the SI; b) The design and management of the supply chain that includes traceability and the indicators for quality and bio-safety; c) The capacity of the KM conformed by the dimensions of education, formation, cycle of the KM and innovation environment; finally d) the performance of the agglomeration that implies resources and relations of the cluster or industrial group (See numeral 1.5.2. – Chart 6 – Dimensions of the KM).

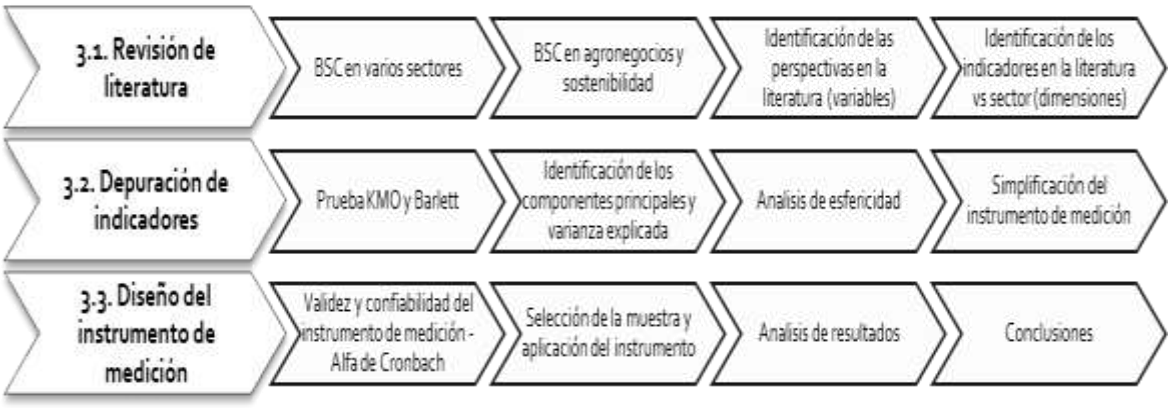
On the other hand, the articles used to extract the dimensions of competitivity measurement in the SI are 3, however this work is centered in the measurement of rentability, that is a subdimension of competitivity (se description in numeral 1.6.2 and chart 3). Among those articles [100] applied a DP and a SWOT analysis for the SI in Denmark [100], then [101] proposed the calculation of rentability of the SSI in the United Kingdom by measuring variables in meso-economic level for the primary, sacrifice and commercial sectors on little scale [101]. Finally [102] studied the competitivity indexes for the SI proposed by IFIP (*French:* Institut du porc Recherche et Expertise pour la filière porcine) applied to the EU [102]. Of this articles the competitivity dimensions applied to the SI were extracted, of which rentability, design and management of the supply chain were chosen [101-103] (See numeral 1.5.1.4.1. – Chart 5 – Dimensions applied to competitivity in the SI).

7. PROPOSED METHODOLOGY

This research Project had a mixed focus of a transversal descriptive study, combining the qualitative and quantitative approach. KM indicators were obtained, later, a data collection via poll was performed on the members of the SSC. Through the management indicators previously selected in a qualitative manner, the same were treated to determine how to articulate the SSC [104].

A sequential and probatory quantitative focus allowed to characterize the processes of the DDC, where the indicators that articulate it were determined. The qualitative focus, where data was collected and analyzed due to the informality of the process. The start was a baseline of theory where data was reunited to expose them to expert judgment in knowledge management and porciculture [104].

Figure 9. Development of research methodology



A measuring instrument design based on the literature review was used, validated by 19 experts dedicated to the Colombian Swine Industry. To check the validity and reliability of the instrument, the alfa of Cronbach was determined, getting 0,927 result, which, because of being higher than 0,8 is considered reliable and replicable for applying it to the sample.

For delimitation effect of the representative sample, the companies dedicated to breed and fattening of wine cattle in the central Andean region were selected, corresponding to the Cundinamarca, Boyacá, Tolima and Huila departments of Colombia. The database of the Bogotá commerce chamber was used, which has 191 companies subscribed that dedicate themselves to swine cattle breeding and fattening, registered until April 12 of 2019 in these departments. Thus, the applied sample was for a finite population using the following equation:

$$n = \frac{N * Z_{\alpha}^{2} * p * q}{e^{2} * (N-1) + Z_{\alpha}^{2} * p * q} \qquad \text{(Equation 1)}$$

Where,

n = Target sample size
N = Size of the Population or Universe
Z = Statistical paramenter of normal distribution - Level of condifence (NC)
e = Maximum accepted estimation error
p = Probability that the studied event occurs (success)
q = (1 – p) = Probability that the studied event does not occur

Thus, the probability that the event occurs or does not occur is not known, then, by this definition, we use a 0,5 of confidence level as 95%, because of this, the statistic is 1,96 and the maximum estimation error is 0,1. Thus, for the selection of the sample a probabilistic sampling method is used [105] to select the 62 companies.

$$n = \frac{173 * (1{,}96)^2_\alpha * 0{,}5 * 0{,}5}{(0{,}1)^2 * (191 - 1) + (1{,}645)^2_\alpha * 0{,}5 * 0{,}5} = 62 \text{ companies}$$

7.1 OPERATIONALIZATION OF THE VARIABLES

Operational definition of the perspectives that compose the balanced scorecard.

Financial perspective: Defines how the actionists of the company are seen, is measure qualitatively and is considered the most important because it evaluates the final result of the company [44, 73, 79].

Indicators related to costs:

- Internal costs [43]
- Fixed costs [82]
- Variable costs [82]

Indicators related to rentability:

- Global rentability (ROE, ROA, ROI, ROS) [42]
- Benefit margin [42]
- Earnings per action [42]
- Cost of the actions [42]
- EBITDA [42]
- Deadline for the payment of obligations [42]

- Auto financing quotient [42]
- Operational return of actives (ROA – *Spanish: retorno operacional de activos*) [79]

Indicators related to incomes:

- Sell volume [43]
- Increase earnings [77]
- Sales of growth [42]
- Overseas sales [42]
- Market shares [42]

Utility related indicators:

- Benefit margin [82]

Expenses related Indicators:

- Depreciation expenses [82]

Client perspective: Defines how we must see the clients, the products of the offered services, like satisfying the market, it is considered the second in importance because our clients can define our financial performance [44, 79, 83].

Indicators related to cost:

- Defective products [82]

Indicators related to rentability:

- Client satisfaction [43]

Indicators related to income:

- Increasing the number of clients [77]

Indicators related to client satisfaction:

- Client complaints Quejas de los clientes [82]
- Client satisfaction [42]

Indicators related to demand management:

- Product demand [82]

Indicators related to productivity:

- Improving the client management [77]

Indicators related to quality:

- Improving client satisfaction [77]
- Improving client Fidelity [77]
- Consumer satisfaction [79]

Process perspective: Defines how we must stand out, centers in the CORE processes of the company, their efficiency, innovation and operation [73, 79].

Indicators related to productivity:

- Defects [82]
- Operative efficiency [42]
- Improving the delivery system [77]

Indicators related to innovation:

- Patents [42]
- Process innovation [42]
- Improving the product design process [77]

Indicators related to quality:

- Quality of the product [79]

Learning perspective: This is the continual improving within the company, focuses in the support processes like technology, personnel and processes. Also reflects the collective capacity and is who impulses the other three perspectives forward [76, 79, 83].

Indicators related to costs:

- Providers [82]

Indicators related to human resources management:

- Employees [82]
- Personnel retention [42]

- Employee satisfaction [42]
- Improving employees competences [77]
- Improving motivations [77]

Indicators related to productivity:

- Increasing teamwork time [77]

Indicators related to quality:

- Employee satisfaction [79]

Indicators related to technology:

- Strengthen IT culture [77]

Sustainability perspective: Allows to define the sustainability strategy of the company, allowing the qualitative and quantitative measurement of the companies actions or applied normativity linking the sustainability objectives with actions and performance results [76, 79].

Rentability indicators

- Years in the market [92].

Indicators related to productivity:

- Value added [82]
- Maximum fish capture [82]

Indicators related to environment:

- Greenhouse effect gas emissions [79]
- Energy use [79]
- Deforestation rate [79]
- CO2 emission [79]

7.2 MEASUREMENT INSTRUMENT DESIGN

Chart 6: Measurement instrument

Variable	Dimension	Indicator	Question
A. Design of the supply chain	Physical infrastructure [106]	Type of production	A1. what type o swine production do you have in your farm? [107].
		Productive capacity	A2. how many mother pigs do you have?
			A3. What is the predominant race of the pigs in your farm? [107-109]
			A4. what is the number of piglets obtained per birth?
	Technologic infrastructure [106, 110-117]	Technology [118-120]	A5. Do you use any software, application or platform for the measurement, management and control of your farm indicators?
	Human resource [111-117]	Workforce capacity	A6. How many operative employees do you have per farm?
B. Rentability [117, 121-123]	Financial management	Manufacturing costs [124] [125-129]	B1. Error or re-process cost
			B2. percentage of the administrative cost in respect to the pig sell cost
			B3. Cost per kilogram produced
		Income and sales [106]	B4. Income per kilogram produced
			B5. Monthly total sales
		Utility [117]	B6. Utility per pig or lot produced
			B7. Percentage of farm utility
		Cost [117, 125, 126, 130, 131]	B8. Cost of the pig in the market per kilogram
	Leverage	Providers	B9. Time of debt or credit
			B10. How many days of debt or credit do you have as average with the feeding companies?
		Clients	B11. How many days of credit do you give your clients as an average?
C. Management of the supply chain	Productivity [106, 117, 129, 132, 133]	Reproduction	C1. Male reproductive efficiency
			C2. Amount of female pigs selected for replacement
			C3. Food consumption per female pig
			C4. amount or percentage of births per female pig before replacement [109]
			C5. Amount of pigs per birth [109]
			C6. Amount of pigs born per week

Variable	Dimension	Indicator	Question
			C7. Amount of stillborn pigs [109]
		Lactation	C8. Amount of pigs dead before lactation end [107]
		fattening	C9. Consumption of food per pig or lot of pigs
			C10. Food consumption per week
			C11. Kilograms earned per week
			C12. Total fattening time before sale
	Quality management [123, 125, 126] [129]	Client [120]	C13. Number of clients lost per year
			C14. Number of effective clients
		Client satisfaction	C15. Follow-up of client satisfaction (in terms of color of produced meat, amount of fat and performance or yield)
	Environmental	Community	C16. Amount of complains from neighboring farms
		Energy	C17. Consumption of electrical energy per pig
		Water	C18. Consumption of water per pig
		Liquid residue	C19. Destiny of the waters after pen washing
		Solid residue	C20. Management of solid residues
D. Knowledge management	Internal performance	Retention programs	D1. Level of personnel rotation
		Education and training [119, 120, 129] [134]	D2. Amount of training received by the personnel per year
		Education level [117, 123, 129, 135]	D3. Employee education level
	External performance [106, 124, 134, 136]	Knowledge sharing [106, 136]	D4. Would you agree to share information about the indicators in a platform oriented towards knowledge management of the actors in the porcine industry?

8. DESCRIPTION OF THE PROJECT

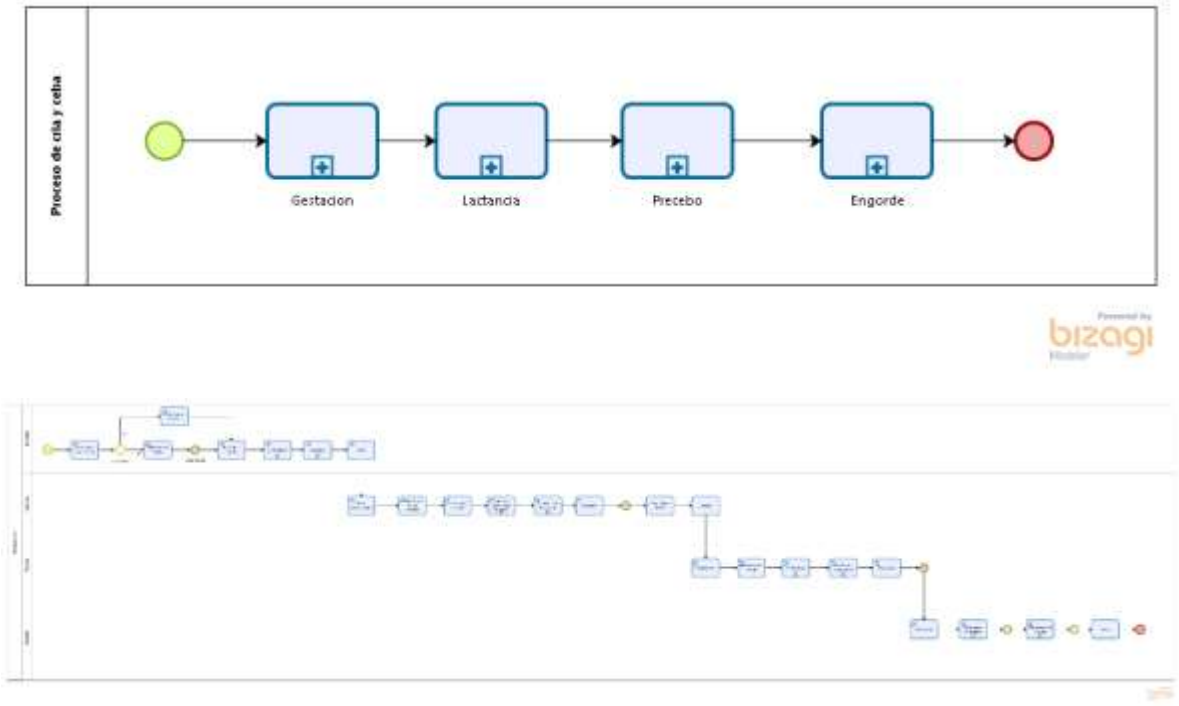
8.1 CHARACTERIZATION OF THE PROCESSES AND THE GROUP OF CURRENT INDICATORS FOR THE KNOWLEDGE MANAGEMENT OF THE SWINE SUPPLY CHAIN (SSC)

The four processes defined within the SSC that are part of this project are:

- Pregnancy
- Lactation
- Pre-fattening
- Fattening

These processes are described next:

Figure 10. Macroprocesses of the SSC



8.1.1 Description of the pregnancy process

Objective:

To describe the pregnancy process of the wires within a porcine farm.

Reach:

This process describes the activities relating since the string is apt to be impregnated until the birth of the piglets

Exceptions:

- This process was documented in non-technified farms.

Considerations:

- This process was documented in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca.
- The birth of a female pig must occur after 9 months and it must be after her first heat cycle, the pig must be over 105 kilos.
- These farms use male pigs for insemination of the female pigs due to costs.

Process:

1. Selection of the female pigs in heat: The female pigs in heat or apt to be ridden by male pigs or artificially inseminated are identified.
2. Selection of the male: If the insemination is natural, a male according to the female weight and size is selected in order to avoid damage or lesions to the female.
3. Artificial insemination: If its artificial insemination, it is done through a dispensable plastic pipe that contains the male semen, it must be done carefully to avoid injuring the female, it is recommended to immobilize the female for this process.
4. Insemination by mount: If it is by mount, the animals are isolated in one pen, which must be dry, previously washed and disinfected.
5. Number of mounts: If the female pig is gilt it requires even three mounts by the boar. If the female pig is a sow it requires only two mounts. It also custom to leave the female pig a maximum 2 days with the boar.
6. Identify the pregnancy: If the female does not show signs of heat after three weeks of the mount or insemination it is considered pregnant.
7. Transportation to the pregnancy pen: Once the gilt is pregnant, it is separated from the male and transported towards another pen, a gestation pen, where she will remain alone until birth. This pen must remain dry, clean and disinfected.

8. Feeding ang care: During the time of the pregnancy, approximately 114 days, the gilt is fed in an abundant form with food rich in nutrients and water at will. In this task usually the amount of food eaten by the gilt is measured.
9. Care: It is important to monitor the gilt and keep daily contact so that in case it needs help during birth it is receptive to aid or intervention.
10. Birth: For the birth, the gilt is taken a few days before to the birth pen or cage, where it will give birth and remain with the piglets until the end of lactation, the birth can last between 2 and 6 hours. The birth must be observed in case of inconvenient and need to help the gilt. In this task usually the number of birthed piglets is measured (alive and stillborn).

Figure 11. Flux diagram of the pregnancy sub-process

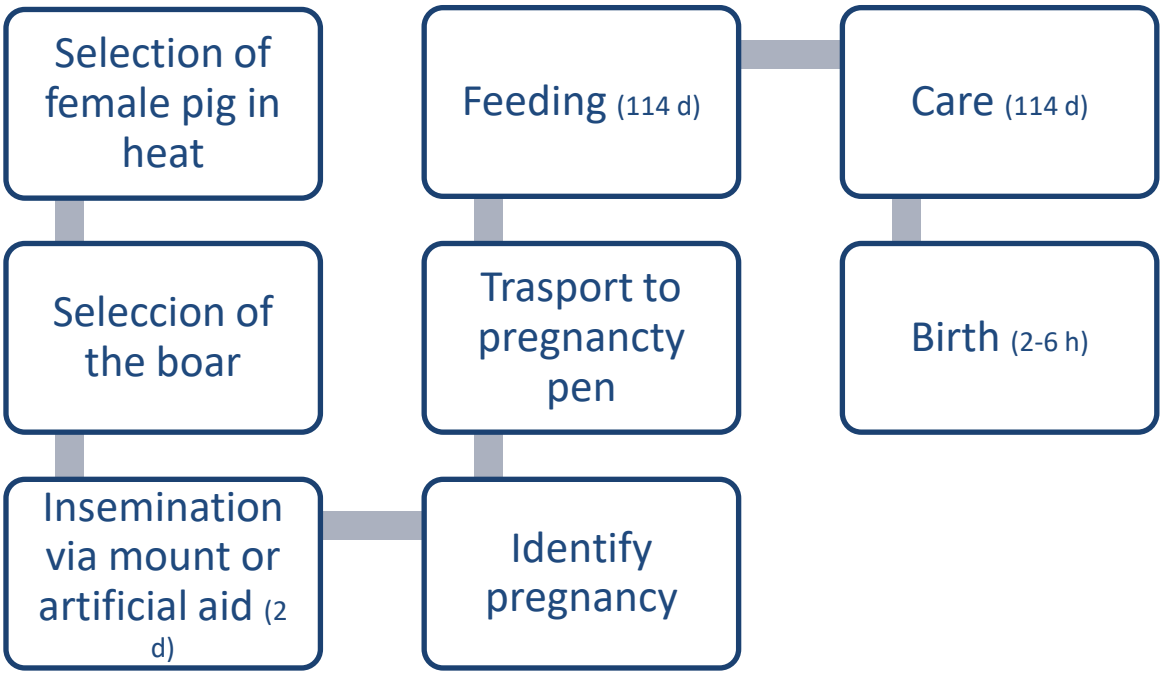
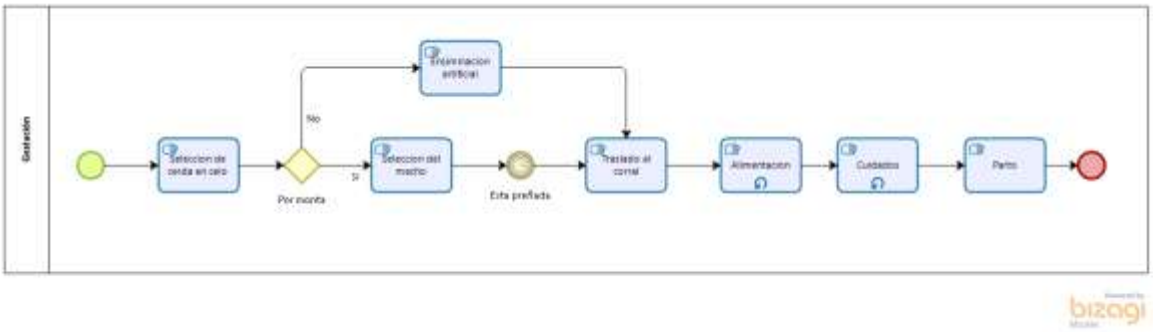


Figure 12. BPMN (Business Process Model and Notation) Diagram of the pregnancy subprocess



8.1.2 Description of the lactation process.

Objective:

To describe the process of the piglets in the process of lactation in a porcine farm.

Reach:

This process describes the activities related since the pig gives birth to the piglets until the lactations is ended.

Exceptions:

- This process was documented in non-technified farms.

Considerations:

- This process was documented in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca.
- This is a natural process where certain recommendations are given to reach an optimal and healthy growth of the piglets, avoiding deterioration of the gilt.
- The main purpose of this process is to avoid the death of the piglets as well as increasing their weight gain.

Process:

The lactation process is a natural process between the gilt and its piglets that last approximately 18 to 22 days, in this process the following main recommendations must be followed:

1. Conditioned pen: The pen must count with floors that allow its washing and fast dry. Canaled plastic floors are recommended. The sow in the birth pen

must have a division where the can feed and drink water, as well as lay comfortably to feed the piglets avoiding their crushing.

2. Identification of the piglets: After the birth each piglet must be associated to a lot, have its sex identified and must be weighted, controlling their advance in weight and health.
3. Piglet vaccination: The piglets must be vaccinated and/or given supplements via vaccine for two days.
4. Pen conditions and cleaning: The pen must be cleaned constantly in order to avoid the piglets and the sow from getting sick. The piglets must be guaranteed an approximated temperature inside the pen of 30 degrees Celsius, heat lamps can be used according to the location off the farm.
5. Sow feeding: The sow must be nurtured with food rich in iron and abundant water to ease the lactation and milt that strengthens the piglets. In this phase usually the amount of food given to the sow is measured.
6. Conditions of the pen: Castration: Approximately 15 days after birth the piglets must be castrated.
7. Preparation of lactation ending: Before ending the lactation, the piglets are given a balance food special for them, a mix based on the food they will be eating as adults in order to accustom their digestive system to it. In this stage the amount of food prepared for the piglets is usually measured.
8. End of lactation: It is done in day 18 to 23 after birth and when they have an approximate weight of 6 kilogram, when the mother is taken to the gestation pen to wait for new insemination. The piglets are vaccinated and taken to pre-fattening pens.

Figure 13. Flux diagram of the lactation subprocess

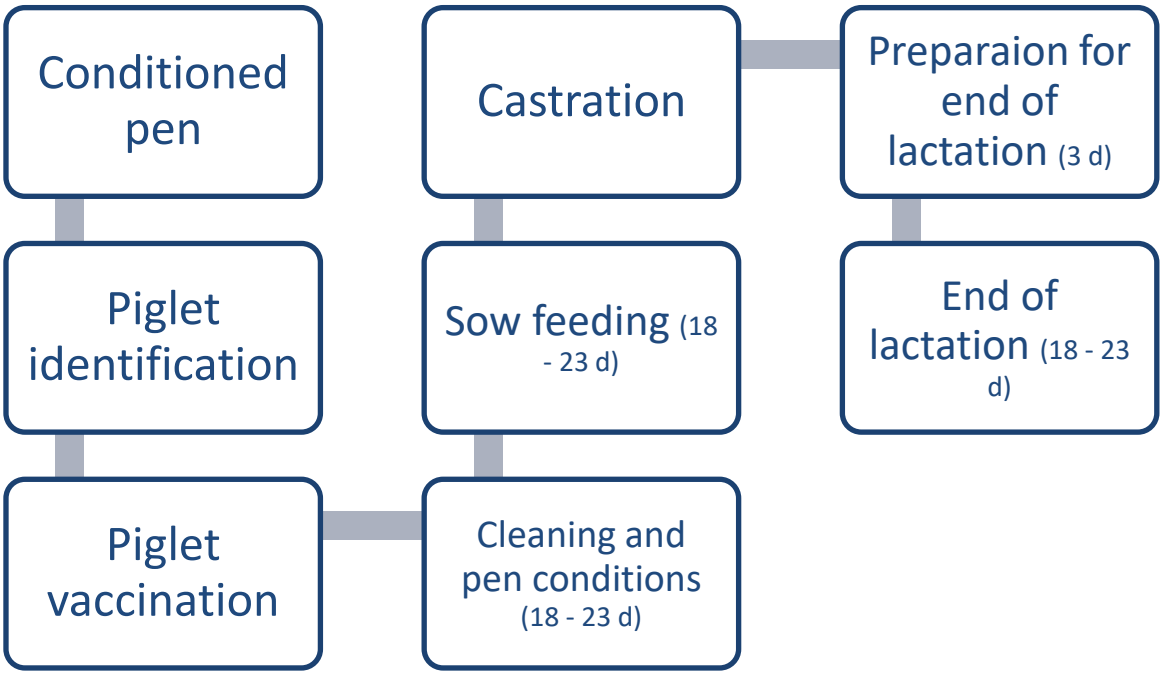
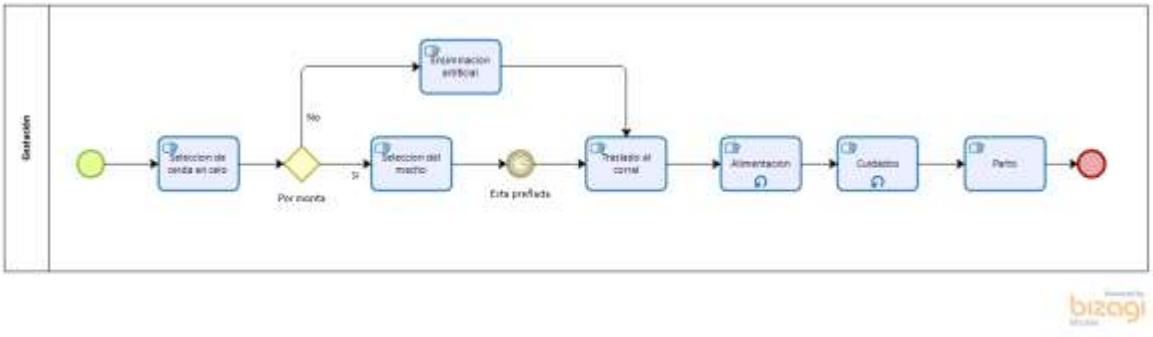


Figure 14. BPMN diagram of the pregnancy subprocess



8.1.3 Description of the pre-fattening process

Objective:

To describe the process of pre-fattening of the piglets that ended lactation in a porcine farm.

Reach:

This process describes the activities related since the piglets end lactation until they start the fattening stage.

Exceptions:

- This process was documented in non-technified farms.

Considerations:

- This process was documented in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca.
- The main objective of this process is to achieve the piglet to adapt to an environment away from the mother and starts to gain weight.

Process:

1. Separation: After the end of lactation the piglets are separated according to their size in lots, preserving their birth lot, the objective is that the animal adapts to an environment without the mother, starts to feed by itself and takes water from the drinkers.
2. Adaptation to the pen: The pens must be kept controlled because in this stage the pigs are susceptible to contracting disease or get sick due to insufficient adaptation to the new food.
3. Feeding: During the pre-fattening three or four foods are given, they are based on flour, soy, corn and oil complemented with minerals, vitamins and nutrients, the objective is to adapt the pig to the new foods and start its weight gain. They usually start with a puree-type food and end with a hard-dry processed food. In this stage the amount of food consumed by the pigs is usually measured.
4. Temperature control: The temperature is kept at 29-30 degrees, each week it is lowered 2 degrees until reaching 26-27 Celsius degrees, the usual environmental temperature for the pig. Here adaptations are needed for the pens, having controlled temperatures, avoiding plagues, flies and insects.
5. Vaccination: The pigs are vaccinated at average in day 60 against the swine flu, this vaccine is mandatory in our country.
6. End of pre-fattening: At 70 days of life the pre-fattening stage ends, the pig must weight an average of 30 kg for transport to the fattening area.

Figure 15. Flux diagram of the pre-fattening subprocess

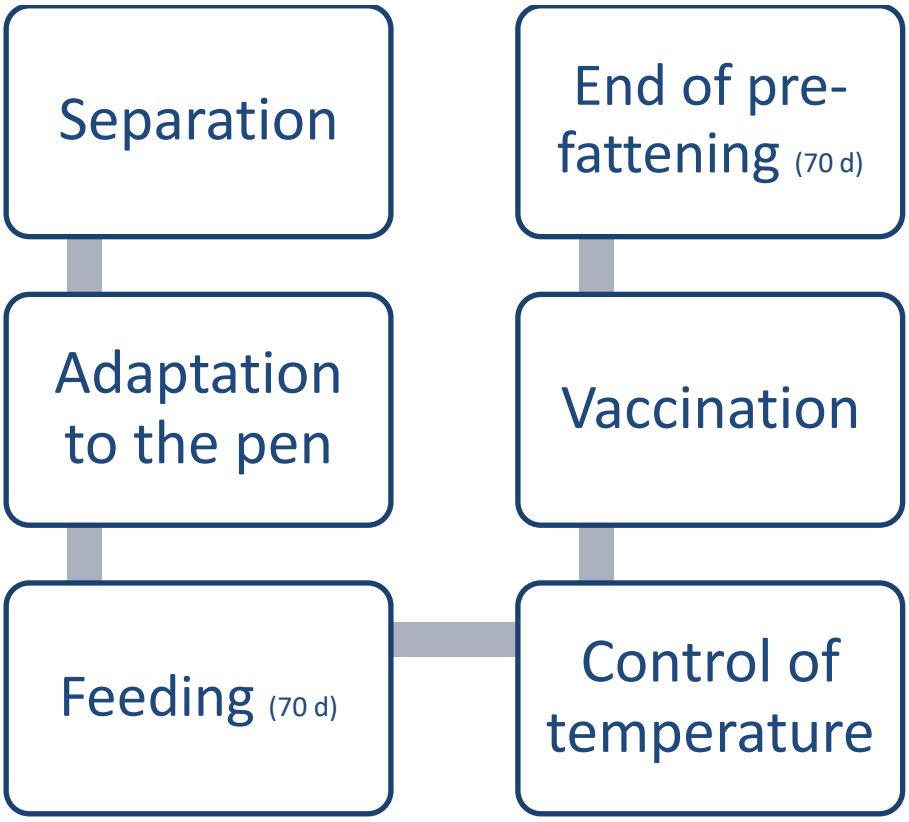
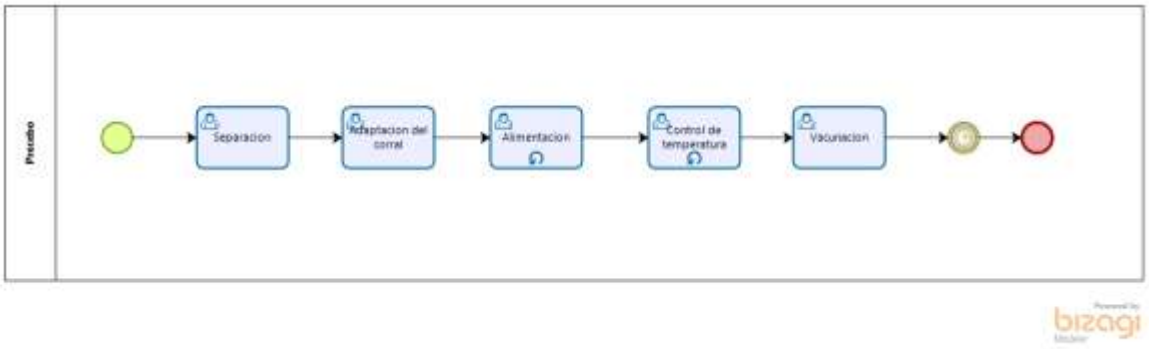


Figure 16. BPMN diagram of the pre-fattening process.



8.1.4 Description of the fattening process

Objective:

To describe the process of piglet fattening from the end of pre-fattening in a Colombian porcine farm.

Reach:

This process describes the activities related since when the piglets exit the pre-fattening process until they are apt in time and in ideal weight to be commercialized.

Exceptions:

- This process was documented in non-technified farms.

Considerations:

- This process was documented in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca.
- The main objective of this process is to achieve the pig to gain an approximate weight of 115 kilos in an approximate time of 4 months for its sale.

Process:

1. Separation: After the pre-fattening the pigs are taken to pens or fattening barns, where they are mixed with other pigs without losing their traceability, it is recommended that the flor be in rice husks so that when mixed with manure a compost for fertilizer be created, which can be picked up every 6 months.
2. Controlled feeding: It is recommended to be changed according to the nutritional profile, giving food twice day with permanent water in the drinkers.
3. Feeding at will: After two months in fattening the pigs can be left with feeding at will, where the pig haves permanent food and water. In some places this is seen as a waste of food, because of this, some farms continue with controlled feeding. In this stage the consumption of food by the pig lot is measured.
4. Sale: After approximately 165 days of age the pig must be around 115 kilos and is apt for sale. In this stage the kilos on foot produced by the farm are measured, having into account the cost per kilo in the market.

Figure 17. Flux diagram of the fattening subprocess.

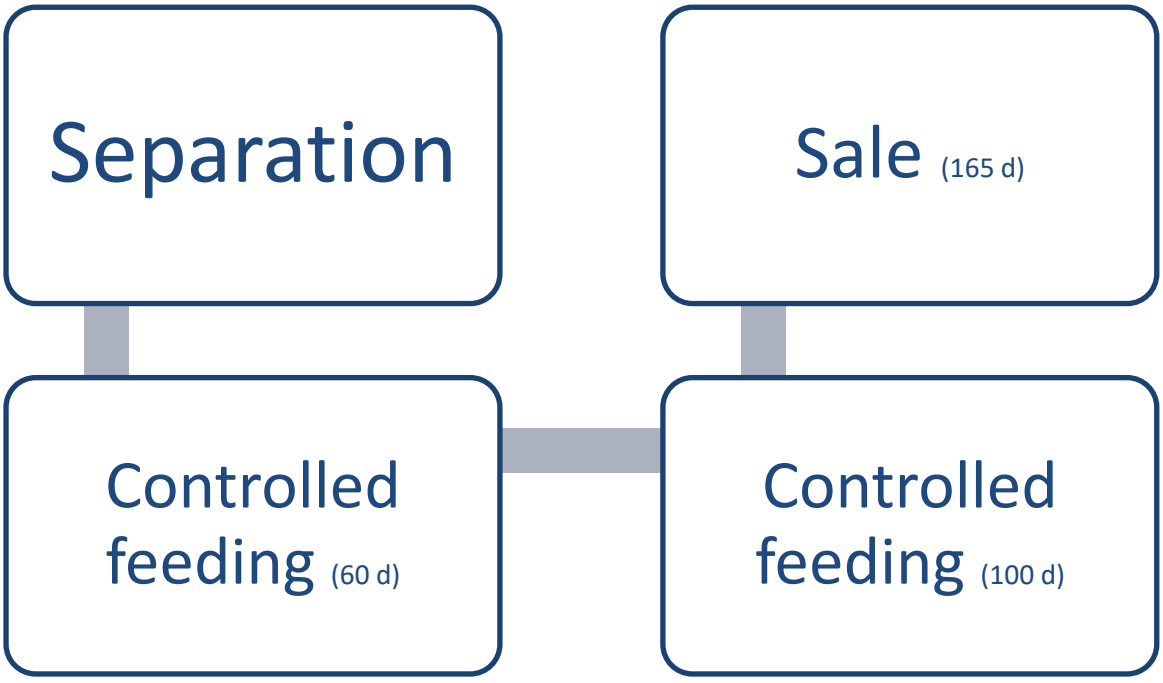
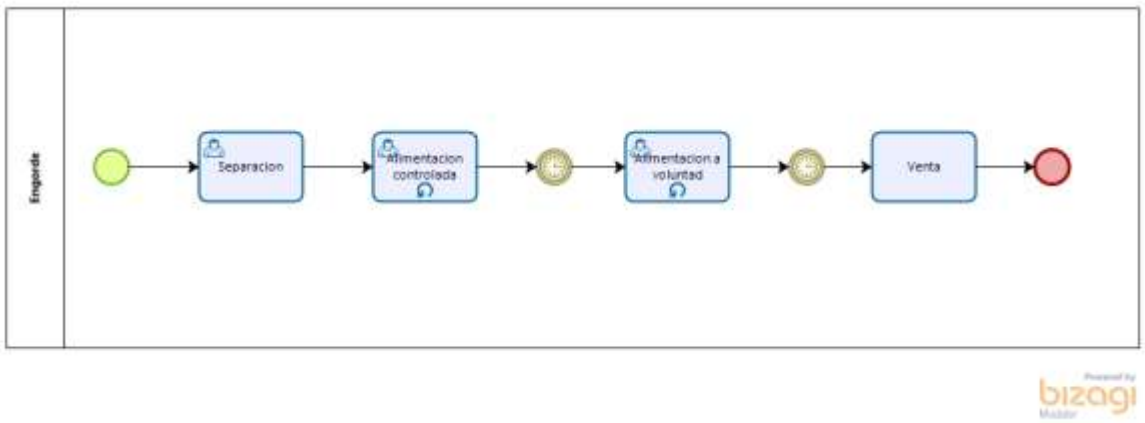


Figure 18. BPMN diagram of the fattening process



8.2 PRIORIZATION OF THE INDICATORS FOR THE CONSTRUCTION OF A SUPPLY CHAIN SCORECARD (SCBSC) VALIDATING THEM WITH THE ACTORS OF THE SSC

From the review of the literature the variables, dimensions and indicators were constructed. The variables reflect in the BSC the financial perspective, the client's perspective, process, innovation, development and learning, in this case the sustainability perspective is including as indicated by Zeynep Kalender y Jae Kyu Myung [76, 79].

Chart 7: Variables, dimensions and indicators

Variable	**DIMENSION** -INDICATOR	
Financial profile: Defines the way the company is seen by the actionists, its measured quantitively and is considered the most important one because it evaluates the result of the company [44, 73, 79]	**UTILITY** Margin of Benefit [42, 82] Aggregated value [82] Utility per action [42] **Income** Volume of sales [43] Increase earnings [77] Growth sales [42] Sales overseas [42] Market shares [42] **Expenses** Depreciation expenses [82]	**COSTS** Internal costs [43] Fixed costs [82] Variable costs [82] **RENTABILITY** [43] Global rentability (ROE, Operational return of actives (ROA) [42, 79], ROI, ROS) [42] Stocks cost [42] EBITDA [42] Term for payment of obligations [42] Self-financing quotient [42]
Client profile: Defines the how the clients are seen, the products or services offered; the satisfaction of the market. It is considered the second in importance because the clients define the financial performance [44, 79, 83].	**CLIENT SATISFACTION** Client management [77] Client complaints [82] Client satisfaction [42, 43, 77, 79]	Amount of clients [77] Product quality [79] Level of client fidelity [77]
Process, innovation and development: Centers in the CORE processes of the company, their efficiency, innovation and operation [73, 79]	**MANAGEMENT OF THE SUPPLY CHAIN** Providers [82] Amount of defective units [82]	**INNOVATION AND DEVELOPEMENT** Amount of patents [42] Process innovation [42] Product and process innovation [77]

Variable	DIMENSION -INDICATOR	
	Productivity [82] Operative efficiency [42] Distribution efficiency [77]	
Development and learning: Focuses on the support processes such as technology, personnel, procedures and continual improvement. Reflects the collective capacity to impulse the other three perspectives ahead. [76, 79, 83]	**EXTERNAL** Years in the market [92] Product demand [82] **TECHNOLOGY** Level of IT culture strengthening [77]	**HUMAN MANAGEMENT** Level of employee satisfaction [42, 79, 82] Personnel retention [42] Improvement of employees competences [77] Improvement of motivation [77] Level of teamwork [77]
Sustainability: Defines the sustainability strategy of the company, from qualitative and quantitative indicators, actions or normativity applied linking sustainable objectives with actions and results of performance [76, 79]	**ENVIRONMENTAL** Level of natural resource exploitation [79, 82] Emission of greenhouse effect gases [79]	Energy consumption [79] CO2 emissions [79]

Source: The author.

The base initial instrument had 42 indicators, however, to depurate this, a new analysis of the main components was made, it was classified by perspective, the test KMO (Kaiser, Meyer and Olkin) had a value of 0.829, which indicates that the relation of the correlation quotients observed between the variables had a high-middle level. The indicators were selected and extracted identifying their fusion with other indicator among the 42, and according to their important, thus, if the indicator decreased the KMO test or the total explained variance it was excluded, getting to 31 indicators.

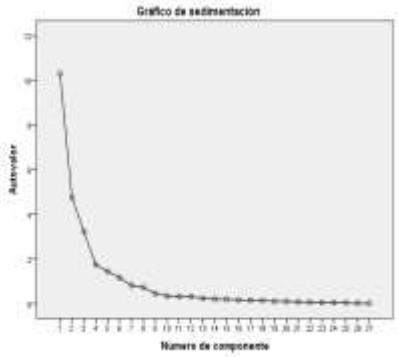
The closer to 1 the result of the KMO test, the higher the relation among the variables; thus, if the KMO ≥ 0.9 the test is very good; notable for KMO ≥ 0.8; middle for KMO ≥ 0.7; low for KMO ≥ 0.6; and very low for KMO < 0.5.

Chart 8: KMO and Bartlett's tests

Prueba de KMO y Bartlett

Medida Kaiser-Meyer-Olkin de adecuación de muestreo		,829
Prueba de esfericidad de Bartlett	Aprox. Chi-cuadrado	1992,547
	gl	351
	Sig.	,000

With the previous information, the sedimentation graph indicates that with 6 of the components the explained variance is high, 83,7% (see7 figure).



Varianza total explicada

Componente	Autovalores iniciales			Sumas de extracción de cargas al cuadrado			Sumas de rotación de cargas al cuadrado		
	Total	% de varianza	% acumulado	Total	% de varianza	% acumulado	Total	% de varianza	% acumulado
1	10,304	38,162	38,162	10,304	38,162	38,162	7,509	27,810	27,810
2	4,747	17,581	55,743	4,747	17,581	55,743	5,163	19,121	46,932
3	3,221	11,931	67,675	3,221	11,931	67,675	3,621	13,413	60,345
4	1,733	6,420	74,095	1,733	6,420	74,095	2,440	9,038	69,382
5	1,439	5,329	79,424	1,439	5,329	79,424	2,075	7,687	77,069
6	1,156	4,282	83,705	1,156	4,282	83,705	1,792	6,636	83,705
7	,805	2,981	86,687						
8	,719	2,661	89,348						

The components and factors are presented in chart 3, which summarizes in 31 key indicators, the nine were extracted using the main components technique because these could be represented by the other 31 depurated, additionally, these decreased the KMO test and the explained variance.

Chart 9: Main components to identify the indicators by perspectives

Perspective BSC	Financial	Client	Process	Sustainability	Extreme learning	Learning human resource	Learning process
Index	1	2	3	4	4	4	4
B3. Cost per produced kilogram	0,384				0,833		
B4. Entry per kilogram produced	0,784						
B5. Total monthly sales	0,856						
B6. Utility by produced pig or lot	0,919						
B7. Percentage of farm utility	0,938						
B8. Pig cost per kilogram in the market	0,797		0,335				
B9. Time of debt or credit	0,906						
C13.Amount of client lost per year		0,607		0,482			
C14. Number of effective clients		0,791					
C15. Follow-up of client		0,825					

Perspective BSC	Financial	Client	Process	Sustainability	Extreme learning	Learning human resource	Learning process
Index	1	2	3	4	4	4	4
satisfaction (in terms of meat color, amount of fat and performance)							
C1. Reproductive efficiency of the male			0,815				
C2. Amount of selected female pigs for replacement			0,796				0,462
C3. Food consumption per female pig.			0,869				
C4. Amount or percentage of births per female pig before replacement			0,887				
C5. Number of piglets per birth			0,931				
C6. Number of piglets born per week			0,934				

Perspective BSC	Financial	Client	Process	Sustainability	Extreme learning	Learning human resource	Learning process
Index	1	2	3	4	4	4	4
C7. Number of stillborn piglets			0,897				
C8. Number of piglets death before ending lactation			0,843				
C9. Food consumption per pig or lot of pigs.			0,732			0,427	
C10. Food consumption per week			0,446			0,781	
C17. Electric energy consumption per pig				0,911			
C18. Water consumption per pig				0,867			
C19. Destiny of wastewaters from the pen's washing				0,923			
C20. Management of solid residues				0,797			
B1. Cost of error or re-process					0,841		

Perspective BSC	Financial	Client	Process	Sustainability	Extreme learning	Learning human resource	Learning process
Index	1	2	3	4	4	4	4
C16. Amount of complaints from neighboring farms					0,603		
D1. Level of personnel rotation			0,448			0,609	
D2. Amount of trainings received by the personnel			0,428			0,585	
B2. Percentage of administrative cost in relation to cost of the product						0,743	
C11. Kilograms gained in weight per week							0,826
C12. Total time of fattening before sale per lot						0,391	0,756

Source: The author

The instrument of measurement as designed and mixing 10 categorical questions that measure the characteristics of the variable and 31 questions about the key indicators, where the Likert scale is used to identify the level of importance and its

application in breeding and fattening companies (see chart 10). The variables of the instrument were constructed from the literature review, which are: a) Design of the supply chain; b) rentability; c) management of the supply chain; d) knowledge management.

Chart 10: Design of the measuring instrument

Variable	Dimension	Indicator	Question
A. Design of the supply chain	Physical infrastructure [106]	Type of production	A1. What type of swine production does your farm have? [107]
		Productive capacity	A2. how many mother pigs do you have?
			A3. What is the predominant race of the pigs in your swine farm? [107-109]
			A4. what is the number of piglets obtained per birth?
	Technologic infrastructure [106, 110-117]	Technology [118-120]	A5. Do you use any software, application or platform for the measurement, management and control of your farm indicators?
	Human resource [111-117]	Workforce capacity	A6. How many operative employees do you have per farm?
B. Rentability [117]	Financial management	Manufacturing costs [124] [125-129]	B1. Error or re-process cost Error
			B2. percentage of the administrative cost in respect to the pig sell cost
			B3. Cost per kilogram produced
		Income and sales [106]	B4. Income per kilogram produced
			B5. Monthly total sales
		Utility [117]	B6. Utility per pig or lot produced
			B7. Percentage of farm utility
		Cost [117, 125, 126, 130, 131]	B8. Cost of the pig in the market per kilogram
	Leverage	Providers	B9. Time of debt or credit
			B10. ¿ How many days of debt or credit do you have as average with the feeding companies?
		Clients	B11. How many days of credit do you give your clients as an average?
C. Management	Productivity [106, 117, 129, 132, 133]	Reproduction	C1. Male reproductive efficiency
			C2. Amount of female pigs selected for replacement

Variable	Dimension	Indicator	Question
			C3. Food consumption per female pig
			C4. amount or percentage of births per female pig before replacement [109]
			C5. Amount of pigs per birth [109]
			C6. Amount of pigs born per week
			C7. Amount of stillborn pigs [109]
		Lactation	C8. Amount of pigs dead before lactation end [107]
		fattening	C9. Consumption of food per pig or lot of pigs
			C10. Food consumption per week
			C11. Kilograms earned per week
			C12. Total fattening time before sale
	Quality management [123, 125, 126] [129]	Client [120]	C13. Number of clients lost per year
			C14. Number of effective clients
		Client satisfaction	C15. Follow-up of client satisfaction (in terms of color of produced meat, amount of fat and performance or yield)
	Environmental	Community	C16. Amount of complains from neighboring farms
		Energy	C17. Consumption of electrical energy per pig
		Water	C18. Consumption of water per pig
		Liquid residue	C19. Destiny of the waters after pen washing
		Solid residue	C20. Management of solid residues
D. Knowledge management	Internal performance	Retention programs	D1. Level of personnel rotation
		Education and training [119, 120, 129] [134]	D2. Amount of training received by the personnel per year
		Education level [117, 123, 129, 135]	D3. Employee education level
	External performance [106, 124, 134, 136]	Knowledge sharing [106, 136]	D4. Would you agree to share information about the indicators in a platform oriented towards knowledge management of the actors in the porcine industry?

Source: The author

The results of the applied poll (look annex 1), are presented next:

Chart 11: Results of the poll application

Question	Category [108][108][108][108][108][108][105][93][74][63][62](Kithinji, Kanui, Ndathi and Mwobobia 2017)(Kithinji, Kanui,	Result

	Ndathi and Mwobobia 2017)				
A1. What type o swine production do you have in your farm? [107]	**Type of technification**			**Percentage %**	
	Traditional			49%	
	Semi – Technified			26%	
	Technified			25%	
A2. How many mother pigs do you have?	Traditional			52 mothers	
	Semi-technified			170 mothers	
	Technified			127 mothers	
	100 mothers 200 mothers 300 mothers >400 mothers			72% 17% 6% 6%	
A3. What is the predominant race of the pigs in your farm? [107-109]	Duroc			19%	
	Hampshire			9%	
	Landrace			17%	
	Landrace-Belgian			11%	
	Pietrain			21%	
	Yorkshire			23%	
	Varied			85%	
A4. what is the number of piglets obtained per birth?	8 piglets 9 piglets 10 piglets 11 piglets 12 piglets			16% 31% 39% 12% 2%	
A5. Do you use any software, application or platform for the measurement, management and control of your farm indicators?	Yes No			23% 77%	
A6. How many operative employees do you have per farm?	Traditional			3 people per farm	
	Semi-technified			6 people per farm	
	Technified			7 people per farm	
Question	**I-LMido**	**I-NoMido**	**Ind.**	**NoI-LM**	**NoI-NoM**
B1. Error or re-process cost	15%	72%	0%	5%	8%
B2. percentage of the administrative cost in respect to the pig sell cost	25%	66%	0%	2%	8%
B3. Cost per kilogram produced	33%	66%	0%	0%	1%
B4. Income per kilogram produced	30%	67%	0%	0%	3%

B5. Monthly total sales	38%	59%	0%	2%	2%
B6. Utility per pig or lot produced	36%	62%	0%	0%	2%
B7. Percentage of farm utility	36%	62%	0%	0%	2%
B8. Cost of the pig in the market per kilogram	33%	64%	0%	0%	3%
B9. Time of debt or credit	26%	66%	2%	0%	7%
B10. How many days of debt or credit do you have as average with the feeding companies?	No credit 30 days 45 days 60 days			7% 43% 30% 20%	
B11. How many days of credit do you give your clients as an average?	No credit 30 days 45 days 90 days			23% 49% 26% 3%	
Pregunta	**I-LMido**	**I-NoMido**	**Ind.**	**NoI-LM**	**NoI-NoM**
C1. Male reproductive effieciency	26%	48%	0%	2%	25%
C2. Amount of female pigs selected for replacement	25%	51%	0%	2%	23%
C3. Food consumption per female pig	30%	52%	2%	0%	16%
C4. Amount or percentage of births per female pig before replacement [109]	30%	52%	3%	2%	13%
C5. Amount of pigs per birth [109]	34%	49%	3%	2%	11%
C6. Amount of pigs born per week	31%	52%	3%	2%	11%
C7. Amount of stillborn pigs [109]	30%	57%	3%	0%	10%
C8. Amount of pigs dead before lactation end [107]	28%	57%	3%	0%	11%
C9. Consumption of food per pig or lot of pigs	26%	62%	0%	0%	11%
C10. Food consumption per week	26%	52%	0%	2%	20%
C11. Kilograms earned per week	21%	62%	0%	5%	11%
C12. Total fattening time before sale	30%	62%	0%	0%	8%
C13. Number of clients lost per year	8%	46%	0%	5%	41%
C14. Number of effective clients	21%	43%	0%	0%	36%
C15. Follow-up of client satisfaction (in terms of color of produced meat, amount of fat and performance or yield)	18%	39%	0%	2%	41%
C16. Amount of complains from neighboring farms	5%	54%	7%	3%	31%
C17. Consumption of electrical energy per pig	11%	52%	0%	2%	34%
C18. Consumption of water per pig	16%	48%	0%	2%	34%

C19. Destiny of the waters after pen washing	16%	51%	2%	0%	31%
C20. Management of solid residues	18%	52%	0%	2%	28%
D1. Level of personal rotation	21%	38%	0%	2%	39%
D2. Amount of training received by the personnel per year	20%	34%	0%	3%	43%
D3. Employee education level	30%	52%	2%	0%	16%
D4. Would you agree to share information about the indicators in a platform oriented towards knowledge management of the actors in the porcine industry?	Yes No			21% 79%	

Chart 12: Characterization of the indicators applied in the poll

Name of the indicator	**Number of swine mothers (CCM – *Spanish: cantidad de cerdas madres*)**
Objective	Measure the amount of swine mothers in the farm
Unit of measurement	Unit
Periodicity	Monthly
Formula	$CCM = Ammount\ of\ swine\ mothers$
Relation	Number of swine mothers: Amount of swine mothers in the farm in one month
Tendency	Ascendance
Responsible	Farm supervisor
Source of information	Operations
State of the source	This information is extracted from the barns where there are swine mothers and is done via manual count.
Baseline data	
This data depends on the size of the farm. A middle size farm is estimated.	
States of measurement	
>70	Excellent
Among (50- 70)	Good
< 50	Insufficient

Source: The autor This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

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Name of the indicator	**Amount of piglets born (CLN – *Spanish: Cantidad de lechones nacidos por parto*)**
Objective	To measure the amount of piglets per birth.
Unit of measurement	Amount
Periodicity	Monthly
Formula	$CLN = Amount\ of\ piglets\ per\ birth$
Relation	Amount of piglets born, makes reference to the number of piglets born in a determined period. In this case monthly
Tendency	Ascendance
Responsible	Farm supervisor
Source of information	Operations
State of the source	This information is extracted from the barns where there are swine mothers and is done via manual count.
Baseline data	
This data depends on the size of the farm. A middle size farm is estimated.	
State of measurements	
>13%	Excellent
Among (11- 13)%	Good
< 10	Insufficient

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Cost of error or re-process (CER – *Spanish: Coste de errores o reprocesos*)**
Objective	To measure the value of re-process in the farm.
Unit of measurement	Pesos
Periodicity	Monthly
Formula	$CER = Cost\ of\ errors$
Relation	Cost of errors, makes reference to the amount of money (COP) that the farm must spend or invest in order to correct said mistakes.
Tendency	Descendent
Responsible	Farm administrator or manager
Source of information	Operations and finance
State of the source	This information is extracted from accounting books.
Baseline data	
Depends on the size of the farm, but is recommended to be lower than 2% of the total cost of the farm.	
State of measurements	
<2%	Excellent
Among (3- 5)%	Good
>5%	Bad

The cost of errors is defined as money inverted to solve the inconveniences produced due to mistakes within the production process [137].

Name of the indicator	**Percentage of the administrative cost in respect to the pig sale cost (PCA – *Spanish: Porcentaje del costo administrativo respecto al precio de venta del cerdo*)**
Objective	To measure the expenses that the farm has in respect to the sale cost.
Unit of measurement	Percentage
Periodicity	Monthly
Formula	$PCA = \left(\frac{Ca}{Vt}\right) * 100$
Relation	Where Ca is the monthly administrative cost of the farm and Vt is the monthly sales of the farm
Tendency	Descendent
Responsible	Countability or financial area
Source of information	Countability
State of the source	This information is extracted from accounting books.
Baseline data	
The baseline depends on the size of the farm, but is recommended to be inferior tan 10% of the total cost of the farm	
State of measurements	
>10%	Excellent
Among (14 - 11)%	Good
>15%	Bad

The administrative cost, also called overhead is the cost that the company invests into the support areas, areas that do not belong to the core of the company such as: Human resources, finances, technology [137].

Name of the indicator	**Cost per kilogram produced (CKP – *Spanish: Costo por kilogramo producido*)**
Objective	To have traceability of the total farm cost by kilogram of produced pig.
Unit of measurement	Pesos
Periodicity	Monthly
Formula	$Pc = \left(\frac{CT}{KP}\right)$
Relation	Where, CT is the monthly cost of the farm and KP is the total of kilos produced in the farm during a month
Tendency	Descendent
Responsible	Countable or financial area
Source of information	Countability
State of the source	This information is extracted from accounting books.
Baseline data	
The baseline depends on the size of the farm, but is recommended to be inferior to $6.000 COP. This value must be actualized in the moment of implementation.	
State of measurements	
<6.000 COP	Excellent
Among ($6.900 -$6.000)COP	Good
>$7.000 COP	Bad

The cost of production is the amount of money invested in the farm to produce a kilogram of pig [137].

Name of the indicator	**Income per kilogram produced (IKP – *Spanish: Ingreso por kilogramo producido*)**
Objective	To have traceability of the income or total level of sales of the farm per kilogram of pig produced.
Unit of measurement	Pesos
Periodicity	Monthly
Formula	$IKP = \left(\frac{Vt}{Kp}\right)$
Relation	Where Vt is the total sell and Kp is the total kilos produces by the farm in the month
Tendency	Ascendant
Responsible	Commercial
Source of information	Countability
State of the source	This information is extracted from accounting books
Baseline data	
The baseline depends on the size of the farm. The measurement states must be calculated according to each farm.	
State of measurements	
➢ $2.500 COP	Excellent
Among ($1.500 – 2.500) COP	Good
< $1.500 COP	Bad

Net income, or sale, is the money the farm receives each month from the commercial transactions of its pigs [138].

Name of the indicator	**Total monthly sales (VTM – *Spanish: Ventas totales mensuales*)**
Objective	To have traceability of the income or total sales of the farm
Unit of measurement	Pesos
Periodicity	Monthly
Formula	$VTM = Total\ monthly\ sales$
Relation	Where, total sales are the value obtained from the sale of all the products produced
Tendency	Ascendant
Responsible	Commercial
Source of information	Countability
State of the source	This information is extracted from accounting books
Baseline data	
The baseline depends on the size of the farm. The measurement states must be calculated according to each farm.	
State of measurements	
➢ $ 180 MM COP	Excellent
Among ($ 140 – 180) MM COP	Good
< $ 140 MM COP	Bad

The total sale is the money that the farm receives each month from commercial transactions derived from all of its products, such as: Swine sales, sales from porcine related items, patents, etc [138].

Name of the indicator	**Utility per pig or produced lot (UCP – *Spanish: Utilidad por cerdo o lote producido*)**
Objective	To have traceability of the utilities obtained for each pig or lot of pigs
Unit of measurement	Percentage
Periodicity	Monthly
Formula	$UCP = \left(\frac{Vc}{Vc - Cc}\right) * 100$
Relation	Where, Vc are the total monthly sales of pigs produced by the farm and Cc is the total monthly cost of the farm pigs
Tendency	Ascendant
Responsible	Farm administrator
Source of information	Countability
State of the source	This information is extracted from accounting books
Baseline data	
The baseline depends on the size of the farm. The general recommendation is that the utility be of two digits above 10%	
State of measurements	
>16%	Excellent
Among (10- 15)%	Good
< 10%	Bad

Utilities are the money earned by the company during a commercial transaction or sale [138].

Name of the indicator	**Percentage of the farm's utilities (PUG – *Spanish: Porcentaje de utilidad de la granja*)**
Objective	To have traceability of the total utilities generated by the farm each month
Unit of measurement	Percentage
Periodicity	Monthly
Formula	$PUG = \left(\frac{Vt}{Vt - Ct}\right) * 100$
Relation	Where Vt is the total farm sales in a month and Ct is the total monthly cost of the farm
Tendency	Ascendant
Responsible	Farm administrator
Source of information	Countability
State of the source	This information is extracted from accounting books
Baseline data	
The baseline depends on the size of the farm. The general recommendation is that the utility be of two digits above 10%	
State of measurements	
>16%	Excellent
Among (10- 15)%	Good
< 10%	Bad

Utilities are the money earned by the company during a commercial transaction or sale [138].

Name of the indicator	**Cost of the pig in the market per kilogram (PCK – *Spanish: Precio del cerdo en el mercado por kilogramo*)**
Objective	To have traceability of the price payed in the market per pig kilogram
Unit of measurement	Pesos
Periodicity	Daily
Formula	$PCK =$ Sale cost per kilogram
Relation	Where sale cost per kilogram corresponds to the cost daily paid in the market per kilogram of pig, this price depends on offer and demand, generally is given by the sacrifice plants.
Tendency	Ascendant
Responsible	Market
Source of information	Market
State of the source	Sacrifice plants
Baseline data	
This data depends on the market speculation and is based on offer and demand	
State of measurements	
➢ $8.000 COP	Excellent
Among ($6.000 – $8.000) COP	Good
< $6.000 COP	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Time of debt or credit (TEC – *Spanish: Tiempo de endeudamiento o crédito*)**
Objective	To have traceability in the debt time the farm has with banks and credit entities
Unit of measurement	Months
Periodicity	Annually
Formula	$TEC = time\ of\ debt$
Relation	Where, the time of debt is the total debt time to the banks
Tendency	Descendent
Responsible	Farm administrator or manager
Source of information	Financial
State of the source	This information is extracted from accounting books
Baseline data	
The ideal is that the farm does not need debt in order to operate or that the debt time be as short as possible	
State of measurements	
<12 months	Excellent
Among (12- 24) months	Good
>24 months	Bad

The debt is the money the farm requests loaned to a bank to leverage their operation. It indicates how much debt a company uses to finance their actives in relation to the net patrimony [138].

Name of the indicator	**Time of debt or credit with swine food providers (TEP – *Spanish: Tiempo de endeudamiento o crédito con los proveedores de purina*)**
Objective	To have time traceability of the debt time that the farm has with the swine food providers.
Unit of measurement	Months
Periodicity	Semesterly
Formula	$TEP = time\ of\ debt$
Relation	Where time of debt is the total time of debt to the swine food providers
Tendency	Descendent
Responsible	Farm administrator or manager
Source of information	Financial
State of the source	This information is extracted from accounting books
Baseline data	
The ideal is that the farm does not need debt in order to operate or that the debt time be as short as possible	
State of measurements	
<1 month	Excellent
Among (2- 3) months	Good
>3 months	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Time of credit to client sales (TCC – *Spanish: Tiempo de crédito en venta a los clientes*)**
Objective	To have traceability of the time given to the clients to pay the swines bought
Unit of measurement	Monthly
Periodicity	Annually
Formula	$TCC = time\ of\ credit\ to\ clients$
Relation	Where, time of credit to clients is the time pacted between the farm and the client for the payment of the sold products
Tendency	Descendent
Responsible	Farm administrator or manager
Source of information	Financial
State of the source	This information is extracted from accounting books
Baseline data	
The ideal as well as the tendency is that there is no credit on sales, however the farms offer some clients credit for up to 30 days	
State of measurements	
< 10 days	Excellent
Among (30 - 10) days	Good
> 30 days	Bad

Credit sale, is a type of operation where the payment of the acquired good or service is done on a short or medium term [138].

Name of the indicator	**Male reproductive efficiency (ERM – *Spanish: Eficiencia reproductiva del macho*)**
Objective	To have traceability of the reproductive efficiency of the male
Unit of measurement	Numeric
Periodicity	Semesterly
Formula	$ERM = Male\ reproductive\ efficiency$
Relation	Where the male reproductive efficiency is the evaluation given to the male according to the number of piglets
Tendency	Ascendant
Responsible	Farm veterinarian or technician
Source of information	Analysis of the swine meat produced
State of the source	Information extracted from clients, laboratories and slaughterhouse
Baseline data	
The baseline is established by each farm according to the pig's race and their standards	
State of measurements	
>9	Excellent
Between (7- 8)	Good
< 6	Bad

The male reproductive efficiency, can be measured in a scale of 1 to 10 according to the meat evaluation, muscle and thickness of the piglets [139].

Name of the indicator	**Number of female pigs selected for replacement (CCR – *Spanish: Cantidad de cerdas seleccionadas para reemplazo*)**
Objective	To have traceability of the number of female pigs selected to replace the reproducing female pigs.
Unit of measurement	Unitary
Periodicity	Monthly
Formula	$CCR = Number\ of\ female\ pigs\ for\ replacement$
Relation	Where the number of female pigs for replacement equates to the number of female pigs that the farm selects to replace the older mother gilts
Tendency	Ascendant
Responsible	Operations
Source of information	Indicators of births per mother pig and number of piglets per birth
State of the source	This information must be obtained from the operative statistics
Baseline data	
Established by the size of the farm, the ideal is to have two female pigs for replacement for every retiring pig mother	
State of measurements	
>3	Excellent
2	Good
< 1	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Food consumption per mother (CAC – *Spanish: Consumo de alimento por cerda*)**
Objective	To have traceability of the amount of food consumed by a mother pig.
Unit of measurement	Kilograms
Periodicity	Monthly
Formula	$CAC = kilograms\ of\ food\ per\ mother\ pig$
Relation	Where kilograms of food per mother pig is the amount of food in kilos that a mother consumes in the established time period
Tendency	Horizontal
Responsible	Farm supervisor
Source of information	Operations
State of the source	Daily registry pf food given to the mothers
Baseline data	
Established by each farm according to their size and producing race. Also influenced if other kind of natural foods are given to the pigs.	
State of measurements	
< 120 Kg	Excellent
Among (120 – 150) Kg	Good
➢ 150 Kg	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Number of piglets born per week (CCP- *Spanish: Cantidad de cerdos nacidos por semana*)**
Objective	To have traceability of the number of piglets born per week on the farm
Unit of measurement	Unity
Periodicity	Weekly
Formula	$CCP = Number\ of\ piglets\ born$
Relation	Where number of piglets born equates to the piglets born in the established time period by the farm
Tendency	Ascendant
Responsible	Farm supervisor
Source of information	Operations
State of the source	Registry of births per mother pig
Baseline data	
It is established by each farm according to the number of female pigs and the secuence of births	
State of measurements	
➢ 80	Excellent
Among (50 -80)	Good
< 50	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Number of stillborn piglets per birth (CCM – *Spanish: Cantidad de cerdos nacidos muertos por parto*)**
Objective	To have traceability of the number of stillborn piglets per birth o per week on the farm
Unit of measurement	Unity
Periodicity	Weekly
Formula	$CCM = Number\ of\ stillborn\ piglets\ per\ birth$
Relation	Where the number of stillborn piglets per birth is the number of piglets born dead per birth
Tendency	Descendent
Responsible	Farm supervisor
Source of information	Operations
State of the source	Registry of births per mother
Baseline data	
Established by the farm according to the race and number of piglets born per birth, although the ideal is 0 (zero) piglets dead per birth.	
State of measurements	
0	Excellent
1	Good
>2	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Number of piglets dead before the end of lactation (CMD – *Spanish: Cantidad de cerdos muertos antes del destete*)**
Objective	To have traceability of the number of dead piglets in the farm before the end of lactation.
Unit of measurement	Unity
Periodicity	Weekly
Formula	$CMD = Number\ of\ dead\ piglets\ before\ the\ end\ of\ lactation$
Relation	Where the number of dead piglets before the end of lactation is the number of piglets that die before ending lactation by their mother
Tendency	Descendent
Responsible	Farm supervisor
Source of information	Operations
State of the source	Registry of births per mother
Baseline data	
It is established by the farm according to the race and number of piglets born per birth, although the ideal is to have 0 (zero) piglets dead before the end of lactation.	
State of measurements	
0	Excellent
1	Good
>2	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Food consumption per pig or lot of pigs (CAC – *Spanish: Consumo de alimento por cerdo o por lote de cerdos*)**
Objective	To have traceability in the amount of food consumed by a pig or a lot of pigs until their sale
Unit of measurement	Kilograms
Periodicity	Weekly
Formula	$CAC = Food\ consumed\ per\ pig\ or\ lot$
Relation	Where food consumed per pig or lot is the amount in kilograms that a pig or lot of pigs consumes weekly before reaching their ideal weight
Tendency	Descendent
Responsible	Farm supervisor
Source of information	Operations
State of the source	Registry of food given to the pigs
Baseline data	
Established by each farm according to the race of the pigs or the number of pigs that conform the lot.	
State of measurements	
< 180 kg	Excellent
Among (180 – 200) kg	Good
➢ 200 kg	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Food consumption per week (CAS – *Spanish: Consumo de alimento por semana*)**
Objective	To have traceability of the amount of food given to the pigs in one week
Unit of measurement	Kilograms
Periodicity	Weekly
Formula	$CAS = Consumption\ of\ food$
Relation	Where the consumption of food per week is the amount in kilograms of the food consumed by the pigs in the farm.
Tendency	Horizontal
Responsible	Farm supervisor
Source of information	Operations
State of the source	Registry of the food given to the pigs
Baseline data	
Established by the farm according to their weight and their growth projections	
State of measurements	
< 10 kg	Excellent
Among (10 – 12) kg	Good
➢ 12 kg	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Kilograms of weight gained per week (CAS – *Spanish: Kilogramo en peso ganados por semana*)**
Objective	To have traceability of the number of kilograms gained per week by the pig or lot of pigs.
Unit of measurement	Kilograms
Periodicity	Weekly
Formula	$CAS = Kilograms\ gained\ per\ week$
Relation	Where kilograms gained per week corresponds to the kilos of weight gained by the pigs each week
Tendency	Incremental
Responsible	Farm supervisor
Source of information	Operations
State of the source	Registry of food given to the pigs
Baseline data	
Established in the farm according to the breed produced as well as the type and quality of the food given to the pigs.	
State of measurements	
➢ 4 KG	Excellent
Among (2,5 y 4) KG	Good
< 2,5 kg	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Total fattening time before sale (TTE – *Spanish: Tiempo total de engorde por lote antes de la venta*)**
Objective	To have traceability of the total time the pig undergoes fattening process before sale
Unit of measurement	Days
Periodicity	Semesterly
Formula	$TTE = Total\ fattening\ time$
Relation	Where the total fattening time es the time a pig takes to reach its sale weight
Tendency	Descendent
Responsible	Farm supervisor
Source of information	Operations
State of the source	Registry of daily food given to the pigs
Baseline data	
The baseline depends on the farm, but there are standard times to raise a pig to 110 kilograms	
State of measurements	
< 150	Excellent
Among (150- 164)	Good
> 165	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Amount of clients lost per year (CPA – *Spanish: Cantidad de clientes perdidos por año*)**
Objective	To have traceability of the clients lost each year
Unit of measurement	Amount
Periodicity	Annual
Formula	$CPA = Current\ clients - Last\ year\ clients$
Relation	Where current clients is the amount of clients currently held by the farm and last year clients is the amount of clients who bought last year from the farm
Tendency	Descendent
Responsible	Commercial
Source of information	Commercial
State of the source	Bills
Baseline data	
The baseline depends on the size of the farm	
State of measurements	
<1	Excellent
Between (1- 3)	Good
>4	Bad

The Amount of clients lost in a period is those who no longer buy in the farm and satisfy their needs through competitors [140].

Name of the indicator	**Amount of effective clients (CCE – *Spanish: Cantidad de clientes efectivos*)**
Objective	To have traceability of the effective or concurrent clients during the year.
Unit of measurement	Amount
Periodicity	Annual
Formula	$CCE = Amount\ of\ effective\ clients$
Relation	Where amount of effective clients are those who have generated at least one bill for swine sales.
Tendency	Incremental
Responsible	Commercial
Source of information	Commercial
State of the source	Bills
Baseline data	
The baseline depends on the size of the farm. The mean of the visited farms is taken.	
State of measurements	
➢ 14	Excellent
Among (7 y 13)	Good
< 7	Bad

The amount of effectives, those clients that buy in the farm and those proven via bills [140].

Name of the indicator	**Client satisfaction (SCG – *Spanish: Satisfacción del cliente*)**
Objective	To have traceability of the level of client satisfaction with the farm
Unit of measurement	Unity
Periodicity	Semesterly
Formula	$SCG = Level\ of\ client\ satisfaction$
Relation	Where the level of client satisfaction is the value over the measurement unit that indicates how happy the client is with service offered by the farm
Tendency	Ascendant
Responsible	Commercial y operations
Source of information	Customer service
State of the source	Customer satisfaction polls
Baseline data	
The baseline depends on the scale used by the farm, here a scale from 1 to 5 is proposed	
State of measurements	
5	Excellent
Between (3 – 4)	Good
< 3	Bad

The complaints or reclamations, is the right every individual has to demand a solution to a problem towards a third party [141].

Name of the indicator	**Amount of complaints from neighbor farms *(*CQV – *Spanish: Cantidad de quejas de fincas vecinas*)**
Objective	To have traceability of the amount of complaints from the farm neighbors
Unit of measurement	Unity
Periodicity	Monthly
Formula	$CQV = Amount\ of\ complaints$
Relation	Where amount of complaints is equivalent to the number of complaints the farm receives on a determined period of time
Tendency	Descendent
Responsible	Farm administrator
Source of information	Customer support
State of the source	History of received and attended petitions, complaints, reclamations and suggestions.
Baseline data	
The baseline depends on the farm and its geographic ubication	
State of measurements	
< 1	Excellent
Between (1-2)	Good
➢ 3	Bad

The complaints or reclamations, is the right every individual has to demand a solution to a problem towards a third party [141]

Name of the indicator	**Energy consumption per pig (CEC – *Spanish: Consumo de energía eléctrica por cerdo*)**
Objective	To have traceability of the amount of energy spent per pig in the farm
Unit of measurement	Kilowatts
Periodicity	Monthly
Formula	$CEC = Amount\ of\ kilowatts$
Relation	Where the amount of kilowatts is the number of units in kilowatts that a farm uses in the stablished period
Tendency	Descendent
Responsible	Farm administrator
Source of information	Electricity bills
State of the source	Electricity bills
Baseline data	
The baseline depends on the size of the farm	
State of measurements	
< 300 kwh	Excellent
Among (300 – 450) kwh	Good
➢ 450 kwh	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Water consumption per pig (CAC – *Spanish: Consumo de agua por cerdo*)**
Objective	To have traceability of the amount of water spent per pig on the farm
Unit of measurement	Cubic meters
Periodicity	Monthly
Formula	$CAC = Amount\ of\ cubic\ meters$
Relation	Where the amount of cubic meters is the number of units in cubic meters that the farm consumes in the established period
Tendency	Descendent
Responsible	Farm manager
Source of information	Water Bill
State of the source	Water bill
Baseline data	
Depends on farm size	
State of measurements	
< 10 M3	Excellent
Among (11 – 18) M3	Good
➢ 18 m3	Bad

The consumption of water is regulated by the law 373 of 1997 which establishes the program for efficient use and saving of water [72].

Name of the indicator	**Destiny or process of residual waters (DAR – *Spanish: Destino o proceso de las aguas residuales*)**
Objective	To have traceability of the treatment or processing applied to residual waters from raising swines in the farm.
Unit of measurement	Cubic meters
Periodicity	Monthly
Formula	$DAR = Cubic\ meters\ of\ treated\ waters$
Relation	Where cubic meters of treated waters is the amount of residual waters in cubic meters that the farm uses and treats.
Tendency	Descendent
Responsible	Farm manager
Source of information	Operations
State of the source	Registry of water treatment
Baseline data	
Depends on farm size and water use	
State of measurements	
➢ 1.000 m3	Excellent
Among (800 – 1000) m3	Good
< 800 m3	Bad

The treatment of residual waters is regulated by the por De. 1541/78 Art. 227, Dec. 1594/84 Art. 72, 73, 84,86 [72].

Name of the indicator	**Solid residue management (MRS – *Spanish: Manejo de residuos sólido*)**
Objective	To have traceability of the amount and management of the solid residue generated in the farm
Unit of measurement	Kilograms
Periodicity	Monthly
Formula	$MRS = Solid\ residue\ kilograms$
Relation	Where solid residue kilograms is the amount of solid residues (paper, paperboard, plastic, wood, etc) that the farm generates and manages
Tendency	Descendent
Responsible	Farm manager
Source of information	Operations
State of the source	Registry of the management of solid residues
Baseline data	
Depends on farm size	
State of measurements	
< 50 kg	Excellent
Among (50 – 80) Kg	Good
➢ 80 Kg	Bad

The management of solid reside is regulated by the decree 4741 de 2005 [72].

Name of the indicator	**Level of personnel rotation (NRP – *Spanish: Nivel de rotación del personal*)**
Objective	To have traceability of the rotation level of the personnel in the farm (Talent drain).
Unit of measurement	Numerical
Periodicity	Monthly
Formula	$NRP = Contracted\ personnel$
Relation	Where the contracted personnel makes reference to the amount of new people contracted in the farm with the goal of replace a resignation or personnel retirement
Tendency	Descendent
Responsible	Chief of human resources
Source of information	Human resources
State of the source	Registry of personnel contracts
Baseline data	
Depends on farm size and number of employees	
State of measurements	
< 1	Excellent
Between (1 – 2)	Good
➢ 3	Bad

The level of personnel rotation is a measurement of the amount of people that retire from the farm and the frequency by which they are replaced [142].

Name of the indicator	**Amount of trainings received per year (CCR – *Spanish: Cantidad de capacitaciones recibidas al año*)**
Objective	To have traceability of the amount of trainings received by the farm personnel in a year.
Unit of measurement	Numerical
Periodicity	Semesterly
Formula	$CCR = Amount\ of\ trainings$
Relation	Where amount of trainings is the number of trainings developed by the farm for its personnel in an internal level or through external means.
Tendency	Ascendant
Responsible	Chief of human resources
Source of information	Human resources
State of the source	Registry of trainings done
Baseline data	
Determined by the size and company culture of the farm. The following levels are recommended	
State of measurements	
>4	Excellent
Between (2 - 3)	Good
< 2	Bad

Personnel training in a company is the process by which the employees acquire, actualize and develop knowledge and skills to improve their development within the farm [143].

Name of the indicator	**Employees education level (NE(X) – *Spanish: Nivel educativo de los empleados*)**
Objective	To have traceability of the employee's educational level
Unit of measurement	Numerical
Periodicity	Annual
Formula	$NES = Number\ of\ employees\ with\ primary\ education$ $NEB = Number\ of\ employees\ with\ bachelor's\ education$ $NEP = Number\ of\ Employees\ with\ professional\ education$
Relation	This indicator measures the amount of employees and their education level
Tendency	Ascendant
Responsible	Chief of human resources
Source of information	Human resources
State of the source	Registry of employee's curriculums
Baseline data	
Determined by the size and company culture of the farm	
State of measurements	
➢ 50 % professional	Excellent
(20% - 50%) Professional	Good
< 10% professional	Bad

The education level of the company's personnel is important because the better their education, the better their adaptation as well as their qualitative and quantitative competitivity [143].

Name of the indicator	**Amount of piglets per birth (CCP – *Spanish: Cantidad de cerdos por parto*)**
Objective	To have traceability of the amount of piglets per birth
Unit of measurement	Numerical
Periodicity	Each time a mother pig gives birth
Formula	$CCP = Amount\ of\ piglets$
Relation	Where amount of piglets is the number of piglets received per birth.
Tendency	Ascendant
Responsible	Veterinarian or farm supervisor
Source of information	Operations
State of the source	Registries of births
Baseline data	
Subjected to the race of pigs raised in the farm	
State of measurements	
>12	Excellent
Between (9- 11)	Good
< 8	Bad

Source: The author. This indicator was obtained through interviews and visits developed in the Pinky Pork farm in the city of Fusagasuga – Cundinamarca and complementing with information from the San Antonio farm in the Tenza valley – Cundinamarca

Name of the indicator	**Amount of operative workers (CEO – *Spanish: Cantidad de empleados operativos*)**
Objective	To measure the amount of operative workers the farm has.
Unit of measurement	Numerical
Periodicity	Monthly
Formula	$CEO = Amount\ of\ operative\ workers$
Relation	Where the amount of operative workers is the number of employees that dedicate themselves to the activities related directly to the production of pigs within the farm
Tendency	Horizontal
Responsible	Chief of human resources
Source of information	Human resources
State of the source	Registries of employee's curriculums
Baseline data	
Determined by size of the farm and the number of pigs produced	
State of measurements	
< 6	Excellent
Entre (6 – 10)	Good
➢ 10	Bad

The operative workers are the employees that within the farm are destined to CORE activities of swine production [143].

The pig production of pigs in confinement is considered by the environmental control organisms of many countries as a highly degrading activity for the environment, bringing problems such as physical degradation of the soil, deterioration of the vegetal coverage and air contamination [144].

All solid residues, liquid effluents, atmospheric emissions, non-degradable contaminants (aluminum recipients, mercurial salts, phenolic chemical substances, etc.) must be treated in a rational way to make this activity a sustainable practice [145].

The care of the environment presents various challenges, because of this that many strategies for processing residues from porcine farms have been designed, for example; the pigs, because of being monogastric do not take advantage of 100% of the nutrients in the food, this causes their stools to be rich in nutrients that bacteria use for their metabolism, by treating the pig stools properly it can be used in biodigesters to obtain biogas, which is conditioned via mechanic means for safe use of it, generating a positive impact on the environment [146].

It is also important to treat the residual water of the farms, which if poured with no treatment can cause severe damage to the environment and human health because of their high concentration of organic matter, nutrients and pathogens. The residual waters can be directed and stored in pools, passing them through decantation processes to clean them, applying them chemical processes that allows them to recover their PH and alkalinity with the objective being apt for their use in crops watering [147].

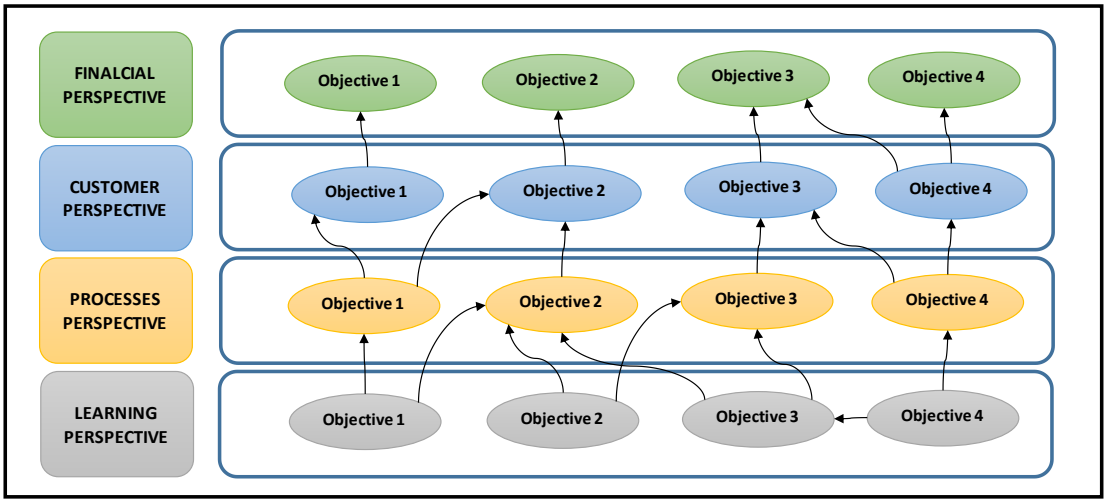
The stools are a resource. They have been an ancestral source of nutrients and organic matter for the fertilization of agricultural soil. This allowed the agrarian industry the green revolution since the sixties and multiply the productivity of the crops by 4 from 1990 to 2000 [148].

The management of the non-degradable residues constitutes a grave problem for the environment, the insufficient final disposition of this residues provokes contamination of water, earth and air. Reuse (recuperation of waste materials that allows through a slight modification the use of the substance or product for their original purpose) or recycling (the product undergoes biological, chemical or physical processing, in order to allow it to be used as prime matter for other products) is the best way to treat these residues [149].

Implementing environmental indicators will allow having a porcine production that is sustainable and friendly with the environment, aligned with the Global Pact Colombia Web and the next principles: 7 (support the preventive focus towards the environmental challenges), 8 (adopt initiatives to promote bigger environmental responsibility) and 9 (promote the development and diffusion of technologies that respect the environment) [150].

For the present project the BSC is hold as planted by its original authors Kappla & Norton, composed by four perspectives (financial, client, process and learning). Every perspective is composed of management indicators and each indicator is accompanied by the strategies that allow the company to reach its goals [151]. Because the porciculture sector is very informal and not used to measuring indicators outside of the financial ones, a BSC of only 4 indicators per perspective is recommended [81].

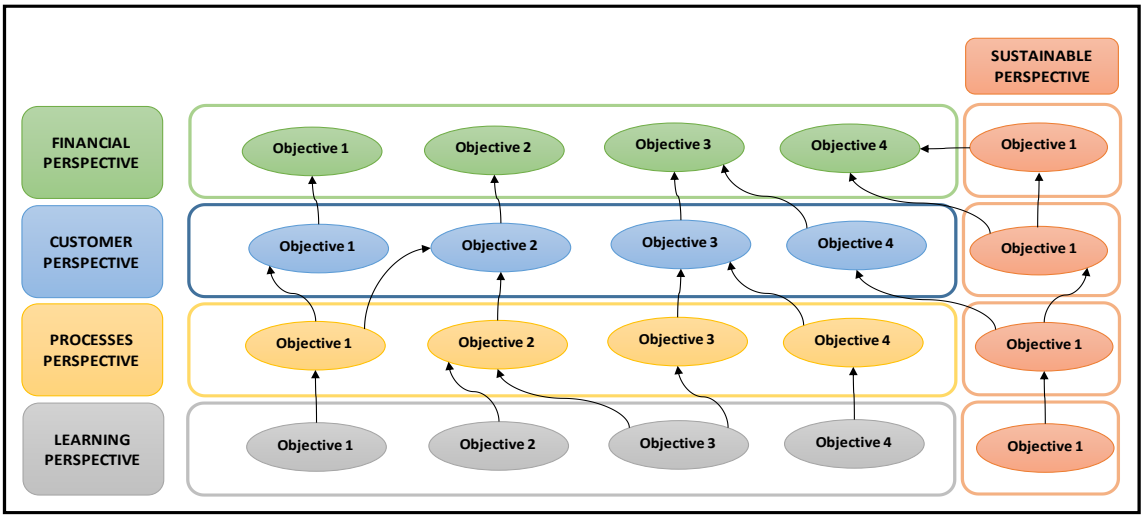
Figure 19. Balanced Scorecard BSC according to the original authors



Source: The author

For the design of a sustainable BSC we oriented ourselves towards a theorical proposal of adding a fifth perspective, sustainability, in order to have a better view of these indicators, which can change and evolve according to the understanding of sustainability by each company, as recommended [76].

Figure 20. Sustainable Balanced Scorecard (SBSC)

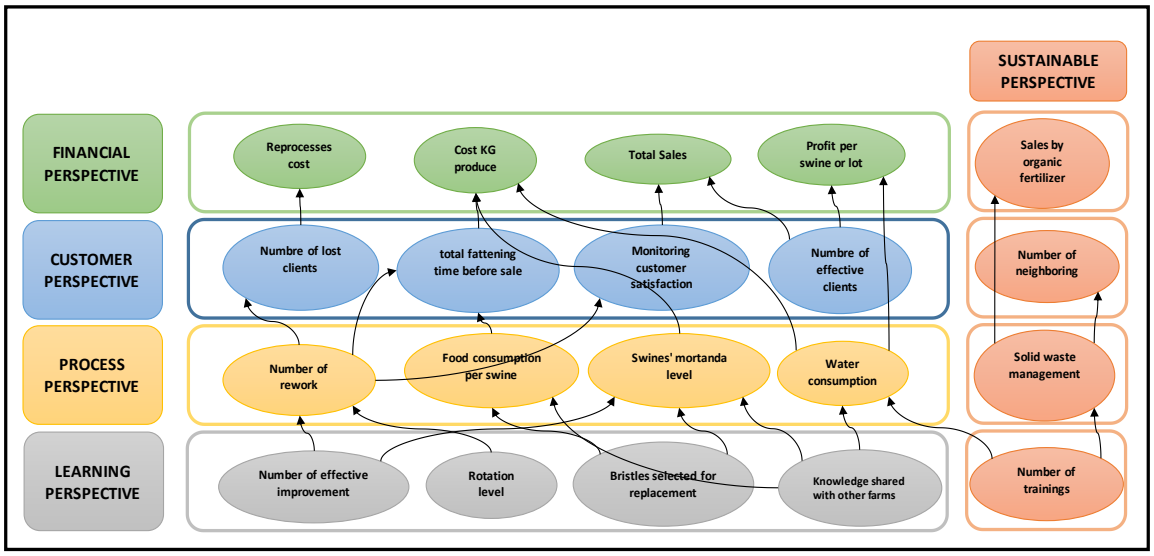


Source: The author

Ahead, we present the proposal of the Sustainable Balanced Scorecard (SBSC) for the swine industry in fattening and breeding at the Colombian Andean region. Only four indicators by perspective were chosen within the SBSC, considering the results of chart 11. The general recommendation is that the steps and strategies

for each indicator must be defined by each company because these depend on their culture and general vision, also, only four indicators were stablished because too many of them could cause confusion and deviate attention from the main strategy, taking into account it is a very informal and without any culture of measurement [76].

Figure 21. Sustainable Balanced Scorecard (SBSC) for the Colombian Swine Industry



Source: The author

8.3 DESIGN OF A MODEL OF KNOWLEDGE MANAGEMENT INTEGRATED WITH THE BSCS FOR THE PHASE OF BREEDING TO FATTENING IN THE SWINE SUPPLY CHAIN

The knowledge management (KM) was born on 1975 [152-154] with the classical theories of [110, 155-158]; In most of the literature it is applied on an organizational level and not in sectors. The KM is connected with the concept ok knowledge economy, which searches that the actors increase rentability, innovation capacity and knowledge transference [159]. The KM is a group of processes and tools to manage and capitalize the people knowledge and the good practices that lead towards competitivity [160, 161], promoting the exchange of information and knowledge on intra and interorganizational level [162], generating programs of academic and work capacitation [163], and attracting qualified personnel to potentialize the industries [164, 165].

In the literature various KM theories have been found oriented towards capitalization of knowledge on an organizational level: i) The model of [166] considered base for

the surge of other KM theories, the author identifies the differences between tacit and explicit knowledge, and explains the knowledge processes, like: a) socialization or interaction; b) externalization or formalization; c) internalization, which makes reference to the conversion of theory into practice; and d) the combination stage, which refers to the unification of the existing theories [167]. ii) Then, an adaptation of the Nonaka model is done by [168] that clasifies the knowlede in an individual, gupal, organizational and interorganizational level; iii) other modification of the base model is done by [168] that clasiffies the knowledge by the ease of transmission as codified and not codiffied, by the speed of sharing as: diffuse and not-diffuse; and adds four new categorizations: patented knwoledge or registered, public, personal and common sense. Lastly, iv) [169-174] establishes the cycles of KM that allow the identification of the stages of the KM process.

Among the knowledge categories can be distinguished: tacit knowledge [175, 176], explicit [175, 176], programed [177], aquired [177], codified or not [168], with/without difussion [168], public [168, 178], registered/patented [168, 177], personal [168, 178]. Likewise, this type of theories of KM have gone into different practices of management and design of supply chains like : a) intra and interorganizational relationship [179-186]; sustainability [187-190], adoption of KM practices [191, 192], information systems [193-195].

For the case of the Colombian Swine Industry (CSI), in [196] it is established that the principles of knowledge management are focused on the measurement of the indicators and the management of good practices.

8.3.1 Knowledge management in the agroindustry

With the previously exposed, first, 7 articles applying specifically for the supply chain in the swine industry (SI) were downloaded, in their importance order is [93] who develops a sofware for KM and vertical integration, validated in four companies in the SI group KOSAROM SA Pascani who produce swine food in Rumania, however it is transversal for all steps of the SI [93], then [197] makes a design of knowledge flux in three agrarian industries polled from the SI that form part of a cooperative system called AURORA, as a result a benefit is observed in the knowledge exchange among them [197] and finally, [95] makes a case study applied to a porcine farm called DF Pork Company in which four habilitators are applied for the creation and management of organizational management [95].

There are other applications for the supply chain in the SI that focus in traceability and design of management indicator and supply chain indicators, for which [96] design a software of traceability for a SI production company in the People’s Republic of China [96], then [97] develop a methodology for the traceability in the SI and peanut industry [97]. However, [98] in the Netherlands applied coordination mechanisms for two SSC [98], and [99] design plans and programs for training in

animal well-being and quality for the SI in Brazil, Chile and Uruguay as tool for the KM [99].

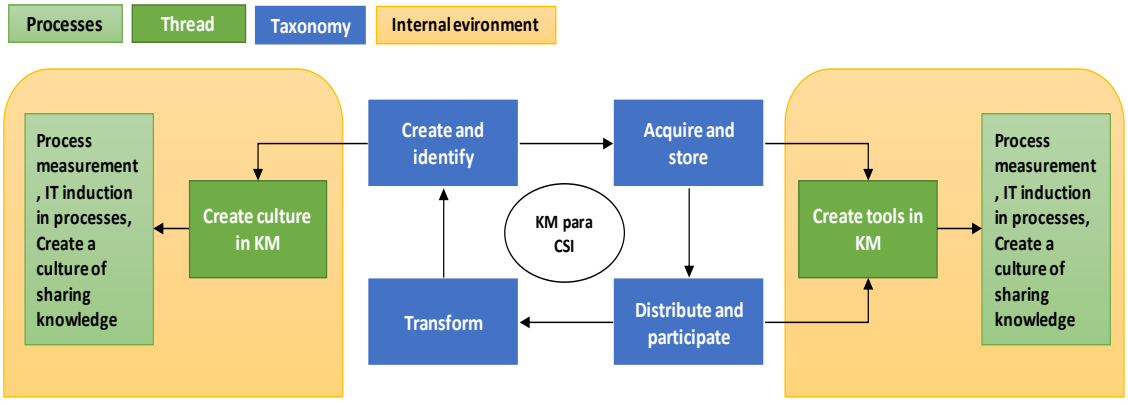
[198] applied a DP and a SWOT analysis for the SI in Denmark [198], then, [101] proposed the calculation of the SI rentability in the United Kingdom measuring variables in meso economic level for the primary sector, sacrifice and small commerce [101]. Finally [102] studied the competitivity indexes for the SI proposed by the IFIP *(french: Institut du porc Recherche et Expertise pour la filière porcine*) applied to the European union [102].

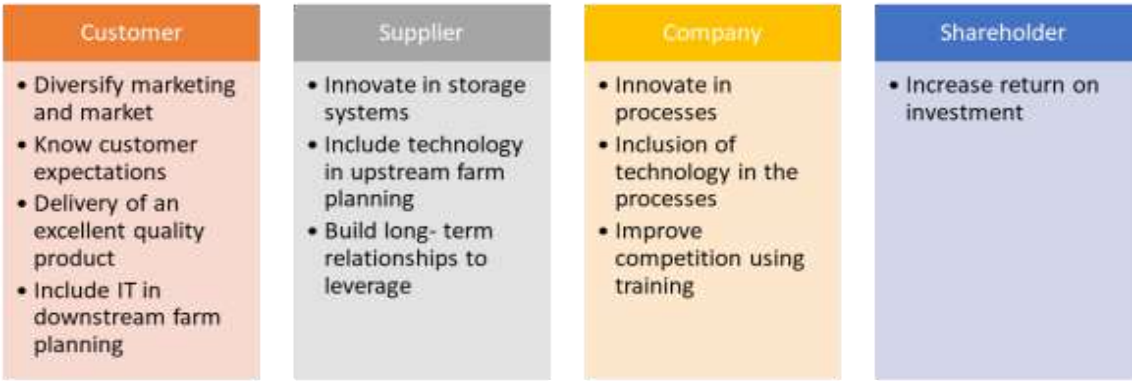
The measure of the indicators potentialize the supply chain towards the process, adding value, innovation capacity [106], competitive advantages in global and uncertanty scenarios [132, 134]. However, the companies do not have knowledge, access to information or use of knowledge transference resources available in the sector just for belonging to said sector [136]. Thus, the KM theories motivate the knowledge capitalization and recognize their role in the competitive adventage in the sectors, under considerations such as confidence, motivation, culture and education among the actors. A capacitated and motivated actor feels his responsibility towards the organizational development and works to improve the bussines processes [134]. Looking at the inventory and definition of the management indicators for the CSI as potencializers of the supply chain, next, we will describe especifically the uses of the command boards or Balance scorecard (BS) in agrarian and porcine sectors.

Based on the prevously stated, the following model of knowledge management for

the CSI is proposed.

Figure 22. Model of knowledge management





The KM is a group of processes and tools to manage and capitalize knowledge of the people and good practices that conduct towards competitivity [160, 161], however as indicated in [196], the companies dedicated to porcine breed and fattening have and ample tacit knowledge [175, 176], but it does not turn easily into explicit knowledge inside the organization [175, 176], due to the lack of KM culture. The KM cycle (see axis 2 – Figure 22) is composed of four phases:

1. **The first is to create and identify knowledge:** In this phase the strengths, potential and local opportunities on disposition to the actors are identified, as well as the local production system efficiencies, composition and variety of processes, products and offered services, all which gives knowledge and helps the CSI [199].

2. **The second one is to acquire it and storage it:** In this phase it is necessary to differentiate among the existing knowledge of the actors or organizations that have a cultural, organizational or relational knowledge collection that contributes to the agrarian development and the knowledge existing outside, either in universities, other countries or research centers. To posteriorly define how and where it is stored and how it is consulted, preferably through a technological system [199].

3. **The third axis is to distribute and share:** This phase is uses in an efficient and effective way all the means of communication available in written, oral or electronic means; be it locally or through the web in order to provide all the actors with the information for the decision-making process. The appropriation, storage and custody of knowledge must be guaranteed by the people or companies receiving it [199].

4. **The fourth is transforming:** This phase can be defined as the action of taking the knowledge to a second phase, taking the existing knowledge, applying it and in this application obtain new or transformed knowledge [200].

Thus, this research is focused in the identification of indicators for the measurement of the processes (See axis 2 – figure 22).

The KM theories motivate the knowledge capitalization and recognize their role in the competitive advantage in the sectors, under considerations like confidence, motivation, culture and education among the actors. A trained and motivated actors feels his responsibility towards the organizational development and works to improve the business processes [134]. With the previously stated, the educational level in the CSI is low and there is not a high level of interest in education (see axis 1 – figure 22), in the model prosed in [196] is proposed to generate programs of work and academic training [163] and to atract quialified personnel to potenciate [164, 165] the CSI.

The second object of the model [196] is promoting the information exchange and the knowledge in an inter and intraorganizational level [162, 179-186], thus in axis 3 (see figure 22), it is directed towards the measurement of processes and the creation of the culture of sharing knowledge to share knowledge, because it is necessary to adopt a culture of KM [191, 192], that allows the implementation of tools, information system [193-195], indicators and good practices that can be shared with the actors (See axis 4 – Figure 22).

Lastly, there is the axis 4 (Figure 22), where the actors have expectations of knowledge transference, that look to identify good practices, benefits, economical incentives, tax reduction, credit programs, innovation and development [201] that the sector needs for the knowledge to be public [168, 178] and of diffusion [168]. Thus, the axis 4, guarantees the KM processes as a) socialization or interaction; b) externalization or formalization; c) internalization that makes reference to the conversion of theory into practice; and d) the stage of combination that refers to the unification of existing theories [167].

In this research, it is established that the principles of KM are focused in the measurement and diffusion of good practices [196] (Axis 1 and 3 – Figure 22). Thus, one of the proposals of this research is to identify the key indicators that impulse the rentability, traceability and organizational management in the CSI, however, in [196] it is also oriented toward the knowledge transference through good practices.

9. RESULTS

Next, we present the results obtained during the execution of the project for every objective planned.

One of the results of this project is the article “Management indexes designing as Knowledge Management enhancers for the Colombian Swine Industry”, it accepted by the magazine Q3 Knowledge Management in Organizations (KMO), and which will be published in July 2020.

9.1 CHARACTERIZE THE PROCESSES OF BREEDING AND FATTENING AND THE GROUP OF CURRENT INDICATORS FOR THE KNOWLEDGE MANAGEMENT OF THE SWINE SUPPLY CHAIN (SSC)

On a general level it is identified that the porciculture sector in the Andean region of Colombia is very informal, the swine cattle raisers are mainly focused on the day to day without taking strong measures to improve or optimize their farms, it is also evident the level of competitivity and withholding of information, although some swine cattle raiser state that they want to receive and share information, it is evident they do not have or know the advantages of a cooperation environment for the sector, such as innovation.

Another important topic is the training of the owners and employees from small farms, most of the knowledge is highly empirical, in some cases their biggest source of information is the veterinarian that visits the farm and makes recommendations.

9.2 PRIORITIZE THE INDICATORS FOR THE CONSTRUCION OF THE SUPPLY CHAIN BALANCED SCORECARD (SCBSC) VALIDATING THEM WITH THE ACTORS OF THE SSC

Next, we present the analysis obtained from the indicators proposed for the CSI.

The costs in the swine industry are important for the “financial perspective” because they represent 73.25%of the total cost [202], according to this study 92% of the swine farms polled consider this indicator important, however only 24% measure it.

In the cost level the heaviest indicator is “*the cost per kilogram produced”*, the 99% consider it important, although only 33% measure it and the lightest indicator is “*cost of errors or re-processes”* where 87% think it is important but only 15% measure it.

On an income and utilities level it is evidenced that 97% of the farms consider this indicators important, but only 34% measure it, seeing “total monthly sell” as the most

measured indicator and the indicators considered most important are "*utility of the farm"* and "*cost per kilogram of the pig in the market",* this indicates a strong tendency in the performance measuring of the is a traditional system base on an accounting measurement [43].

It can be said that 93% of the farms feed their pigs financing the food to 30 days or more with their providers, there 43% of the farms has debt to 30 days and 43% has debt to more than 45 days, but only 23% of the farms sell with no credit, the rest sell on credits to 30 days or more, evidencing that farms work their days with their own capital and the amount of this is directly proportional to the size of their farm. We also found that only 26% of the farms measure their financial debt and the other 74% do not have it controlled.

For the indicators in the "*perspective of the process",* which has the biggest weight within the BSC, because it indicates the critical processes in which the company must stand out [43, 44], we evidenced that only 28% of the farms measure, 54,6% consider it important and do not measure it and the rest do not consider it important, which is worrying if we take into account this indicators measure the CORE of the company and are the ones with a bigger relation with the rise of client satisfaction and financial performance of the company [79].

The study evidences that the strongest indicator is "*total fattening time per lot before sale",* where 92% of the farms consider it as the most important, although 62% do not measure it, the lighter indicators are *"male reproductive efficiency"* and "*amount of female pigs selected for replacement",* where only 74% and 76% respectively consider it important, likewise we found that the most measured indicator by the farms is "amount of piglets per birth", with a 34% and the most important but not measured are the ones related to the food consumption and the kilos gained by the animal with a 62%.

The *client management* is very deficient, the study shows us that only 15% of the farms polled measure the indicators proposed for client management, finding that 43% of the farms consider it important but do not measure it and the rest do not consider it important. About the client perspective and its indicators it is important to highlight that it has a strong impact in the financial perspective [79], because of this to measure and manage this indicators is of high importance for the company's survival.

In this study only 3 indicators are incorporated for the client perspective and the findings evidence that the interest over this indicators is very low, finding that the strongest indicator is "*amount of effective clients"* where 64% of the farms consider it important but only 21% of them measure it, followed by *"follow-up of client satisfaction (in terms of meat color produced, amount of fat and performance)"* where 57% of the farms consider it important but only 18% measure it and lastly we have

"*amount of clients lost per year"* where 54% of the farms consider it important but only 8% measure it.

Of the indicators associated to the *learning and development perspective* we found that only 23% of the farms consider it important and measure it, 41% consider it important but do not measure it and the rest do not consider it important. About this group of indicators grouped as learning and development is important to mention that it is the perspective that allows the company to create value, because the success of the processes depend on the qualified and motivated employees, as well as precise and timely information [44, 73].

Of the indicators of learning and development, the most important indicator is "*educative level of the employees"* with 82% of the farms, however only 30% of them measure it, and the lowest indicator is "*amount of trainings received by the employees in a year"* where 54% consider it important and only 20% measure it exposing the farms to de-actualization of their employees in topics such as processes, are, normativity, sector improvements or tendencies, etc. In this manner, the farms avoid managing the knowledge they could obtain from the training entities. As knowledge is created, share, transferred and applied through and for the people, the small and middle size companies (porcine farms) need to manage the knowledge in humanist way and base themselves on the tacit knowledge of their employees [80].

The swine production in confinement is considered by environmental control organisms of various countries as a highly degrading activity for the environment, bringing problems such as physical degradation of the soil, deterioration of the vegetal coverage and air contamination [144]. About *the sustainability,* we can say that it is a central competency that takes high importance in the agrarian sector, it is a growing concern and a tendency that allows companies to incorporate social and environmental pillars [76, 84]. About the performed study, we suggested only one social indicator focused on "*measure the complaints of neighbor farms",* only 5% of the polled farms considered this indicator important and measure it, 54% consider it important but do not measure it and the rest do not consider it important. About the proposed environmental indicators in this study we found that only 15% of the polled farms consider it important and measure it, 50% consider it important but do not measure it and 35% do not consider it important, showing a big lack of knowledge and interest over the environmental and social impact of the porcine production or simply, is known but they do not care.

9.3 DESIGN A MODEL OF KNOWLEDGE MANAGEMENT INTEGRATED WITH THE BSCS FOR THE PHASE OF BREEDING TO FATTENING IN OF THE SWINE SUPPLY CHAIN

We found that the farms do not know the currents models of knowledge management that aid them to improve their productivity. It is important to highlight that only 21% of the farms polled are willing to share their knowledge with external entities and likewise to receive knowledge from external sources, avoiding the generation of open innovation inability to use external knowledge (other farms) and avoiding investments in research to improve their processes [80].

10. VALIDACION OF THE PROJECT

The validation of this research work focuses on the validity of the content proposed at the level of the indicators contained in the BSCS and the knowledge management model designed for the IPC, specifically through the judgment of judges or experts [203]. Expert judgment can be defined as a concept given by experts (at an academic or empirical level) on the subject to be evaluated. This technique is widespread and must be performed efficiently, with methodical and statistical rigor [204, 205].

A combination of the steps proposed by Skjong y Wentworht (2000), and of Arquer (1995) cited by [204] and the steps to validate an instrument of José Supo [203], which are described below:

- Prepare instructions and instrument: A summary of the project was elaborated explaining the operation of the proposed knowledge management model. In preparing the instrument, the questions were classified into 4 dimensions to group the questions and each dimension represents a phase of the QA model proposed in this project, within each dimension the four categories are evaluated: Clarity, coherence, relevance and sufficiency (See Annex 2).

- Select experts and judges: Judges and experts were selected to validate the QA model proposed in this project, the experts are professionals with experience in knowledge management and the judges are staff with academic level oriented to knowledge management as mentioned [203]. The following Experts were selected for the application.

Chart 13: Characterization of selected judges.

ID	NOMBRE	PREGRADO	POSTGRADO	AÑOS EXP.	CORREO	EXPERIENCIA
1	Diego Alejandro Gutiérrez	Systems Engineer	Msc. Strategic planning Msc. Technology management Quality doctor candidate	19	dialgumo@gmail.com	Quality, innovation and knowledge consultant. Founder and CEO of the company "Validar T"

ID	NOMBRE	PREGRADO	POSTGRADO	AÑOS EXP.	CORREO	EXPERIENCIA
2	Yimi Alberto Acevedo	Industrial Engineer	Msc. In information science	30	yimi.acevedo@gmail.com	Digital transformation consultant University professor and associate researcher of the research group "Information, knowledge and society" Univ. Antioquia Commercial director in documentary strategie
3	Christian Espitia	Systems Engineer	MBA Msc. in innovation	15	christian.a.espitia@gmail.com	Implementer of solutions of high technological component and innovation, to problems in different industries: financial, health, insurance, telecommunications and logistics. Currently Agile Coach.
4	José Alberto Cristancho	Systems Engineer	Esp. In management planning PhD. in education Postdoctorate in Education, research, pedagogy and knowledge	25	jacristancho@gmail.com	Professor Universidad Minuto de Dios, Researcher and consultant

ID	NOMBRE	PREGRADO	POSTGRADO	AÑOS EXP.	CORREO	EXPERIENCIA
5	Carlos Adolfo Oñate	Industrial Engineer	Esp. Financial Management	25	caonate72@gmail.com	General Manager of informa Colombia President of Holding Family office Gerente UEN at Suppla SA Gerente UEN at Almaviva SA 10 years raising cattle
6	Alejandro Celis	Industrial Engineer	Esp. Documentary management	30	acelis@archicentro.com	Founder, President / CEO of US-based IT multinational Grupo Archicentro And presence in 7 Latin American countries
7	Libia Zulay Ariza	Teacher	Msc. In education	15	profesorazulay@gmail.com	Teacher at the Iberoamerican University Corporation in subjects such as Knowledge Management, Research Projects, processes.

- Explain the context and apply the evaluation: The evaluation document of the KM model was sent to the judges and experts, once the answer is obtained, these are tabulated.

Chart 14: Judges' response tabulation

	SUFFICIENCY				CLARITY				COHERENCE				RELEVANCE			
SURVEY	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**	**R12**	**R13**	**R14**	**R15**	**R16**
Diego Alejandro Gutiérrez	5	5	4	4	5	5	5	5	5	4	5	5	5	5	5	4
Yimi Alberto Acevedo	5	5	5	5	2	4	4	5	2	4	4	5	4	2	5	2
Christian Espitia	4	4	5	5	4	4	4	4	4	4	4	4	2	2	2	2
José Alberto Cristancho	4	5	4	4	5	4	4	4	4	4	5	5	5	5	4	4
Carlos Adolfo oñate	5	3	4	4	4	4	5	5	4	3	4	4	4	3	4	5
Alejandro Celis	5	5	4	5	5	4	5	5	5	4	5	5	4	4	5	4
Libia Zulay Ariza	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

- Evaluation of reliability: To evaluate the reliability of the instrument, the Cronbach's Alpha method was selected, described in 1951 by Lee J. Cronbach, which determines a coefficient that measures the reliability of an instrument [206, 207].

  The formula to calculate Cronbach's alpha from the variances is [206]:

Figure 23. Formula to calculate Cronbach’s alpha

$$\alpha = \left[\frac{k}{k-1}\right]\left[1 - \frac{\sum_{i=1}^{k} S_i^2}{S_t^2}\right]$$

The analysis was made through the IBM SPSS software, obtaining the following results:

Figure 24. Cronbach's Alpha calculated with SPSS software

Resumen de procesamiento de casos

		N	%
Casos	Válido	7	100,0
	Excluido[a]	0	,0
	Total	7	100,0

a. La eliminación por lista se basa en todas las variables del procedimiento.

Estadísticas de fiabilidad

Alfa de Cronbach	Alfa de Cronbach basada en elementos estandarizados	N de elementos
,870	,872	16

Cronbach's Alpha has a value of: 0.87, which does not indicate that the reliability and validity of the instrument is good.

- Assessment of consistency: To assess the relevance and relevance of the content, the Hernandez-Nieto 2002 method is used, where the Total content validity coefficient (CVCt) is defined as the average of the content validity coefficients of each item. (Validation survey category), each of which has been corrected for random agreement between judges [208].

Figure 25. Formula method Hernandez - nieto

$$CVC_{ic} = \frac{Mx}{Vmx} - Pe = \frac{Mx}{Vmx} - \left(\frac{1}{J}\right)^{J}$$

Formula obtained from [208].

When applying the Hernández-grandson method we have:

Chart 15: Tabulation of responses by category.

Número de jueces	7

Category	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Exp 6	Exp 7
Phase 1 of the model	18	20	18	17	16	19	20
Phase 2 of the model	20	15	16	17	18	19	20
Phase 3 of the model	19	15	16	18	15	19	20
Phase 4 of the model	19	13	8	18	16	17	20

To apply the formula we have:

N = Total number of items in the data collection instrument.
Sx1 = Sum of the scores assigned by each judge to each of the ítems.
Mx = Maximum value of the scale used by the judges.
Pei = Probability of error for each item.
J = Number of judges.
CVCi = Calculation of the validity of individual content.
CVC = Content validity calculation minus the probability of error.

Chart 16: Calculation of CVCt model Hernandez-nieto.

Sx1	Mx	CVCi	Pei	CVC
128	6,4	0,914	0,0000012	0,914
125	6,25	0,893	0,0000012	0,893
122	6,1	0,871	0,0000012	0,871
111	5,55	0,793	0,0000012	0,793

Average	0,87

The average obtained in the content validity calculation is: 0.87

To perform the Interpretation of the total content validity average, according to [208], we have:

a) Less than 0.60, unacceptable validity and agreement.
b) Equal or greater than 0.60 and less than 0.70, poor validity and agreement.
c) Greater than 0.71 and less than or equal to 0.80, acceptable validity and agreement.
d) Greater than 0.80 and less than 0.90, Good validity and agreement.

Greater than 0.90, Excellent validity and agreement.

According to the previous definitions, the validity and agreement of the proposed model is good.

- Analysis of the results

After tabulating and analyzing the results of our survey, it can be concluded that the instrument is valid and that the content of the proposed knowledge management model is in good agreement.

The judges agree that the proposed knowledge management model is valid.

One of the judges mentions that the BSCS is not necessarily the only useful tool to collect information and evaluate indicators.

One of the judges considers it innovative to include the sustainable perspective within the BSCS.

One of the judges mentions that it was evaluated to involve quality within the knowledge management model, but Quality is considered to be an inherent characteristic within each phase of the model and within each indicator.

At least three judges mention the need to implement the model under a technological tool that facilitates its massification, and one of the judges recommends implementing the BSCS implementation in phases first and then implementing the knowledge management model. It is clarified that the implementation of the knowledge management model is not part of the scope of this project, but will be left as a recommendation for future research.

11. CONCLUSIONS AND FUTURE WORKS

The results of this research have an immediate application in the Colombian Swine Industry, evidencing that the participants of the SSC do not count with a tool that allows them to create, share and generate knowledge towards constant improvement of their productivity, thus, the implementation of this project would have a very positive effect within the sector. Initially this project is focused in the Andean region of the country, but as they evidence the results it can be extended on a national level.

One of the most relevant technical risks is that the porcine sector in Colombia, aside from locating itself in rural zones is very informal, which can result in that identifying he participants of the SSC in breeding and fattening becomes a very wasteful and difficult task, moreover, causing that the small swine cattle raisers do not acquire knowledge about the instruments within the project and do not benefit from it.

Once the results are obtained, this must be given in a free manner to the porciculture sector, incentivizing the fast implementation of them.

Most agrarian companies are oriented towards measuring utilities and sales, not doing a traceability control of the process due to lack of culture, organizational leadership, education level, personnel training, resources, etc. Thus, the decision-making process of this organizations has uncertainty on the market prices due to the lack of understanding of the importance of this for the decision-making process by the leaders of porcine companies. An example is that the cost of feeding is 73,25% of the productive cost [202], however only 33% of the polled measure it and 99% consider it important.

Most of the swine farms of Colombia are semi-technified, this kind of farms consider important most of the indicators presented to them during this research, however, the swine companies need to sensitize themselves with generating a culture of measurement and taking these measures to the decision-making process with more certainty, while using technology with the goal of speeding their processes and supporting this process.

The training and education incentivize the rise of productivity, the continual process improvement and the product quality guarantee; for this, the KM aspect is important to the porcine companies, but few ranches measure it, in spite of this management aspects incentivizing innovation, rentability and automatization of the productive processes.

Within the client perspective, for the agrarian companies there is no follow-up in the client satisfaction and its needs. We found that few are interested in knowing the quality of the meat produced, doing the client management.

In the process perspective a lack of innovation, research and development in the processes can be seen; for example, the traceability of the fattening process lacks search and experimentation of new food sources in order to reduce its cost, the evaluation of the impact in the rentability of having only one race and not many, lack of registry, control and analysis of the feeding schedules, weight gain, etc. strategies that will guarantee the measurement and decision-making process with certainty to improve the productivity and rentability of these organizations.

With the goal of improving the sustainability process of the porcine companies, these must look for new sources of water treatment, pen washing and new uses for the solid residues, like generating organic fertilizer by mixing the stools with rice husks; this could lead to new lines of sustainable business.

According to the recommendations obtained in the expert judgment. The implementation of this project should seek to be done in phases, first implement the BSCS and later the implementation of the knowledge management model, also that said implementation will be carried out through a technological tool that facilitates the capture, use and massification of information.

12. ANNEXES

12.1 ANNEX 1. POLL FORMAT

Respondent's basic data:

Name of the company	
Position of the respondent	
Geographical ubication	

General information of the company:

Total number of employees	
Years in the market	
Approximate sales per year	

Classification of a company within the SSC:
Mark with an X the options in which the company has economic activity.

Input supply		**Animal benefit**	
Primary production		**Pork meat processing**	
On-foot animal commerce		**Wholesaling**	

Indicators of knowledge management that the company measures and manages:

Mark with an X the indicators that the company currently measures and manages in a periodic manner and indicate the minimum value or indicator base. In the field of observation, give your appreciation about the indicator or manifest it, in case of not having it, if you would like to measure it in your company.

Type of indicator	Indicator	Mark with an X if you use the indicator	Value or base value of the indicator considered normal	Range of the indicator considered deficient	Range of the indicator considered excellent	Observation
Environmental	External communications [209]					
Environmental	Energy consumption per animal [209]					
Environmental	Personnel education					
Environmental	Water consumption per animal [209]					
Environmental	Infrastructure [209]					
Environmental	Solid residues [210]					
Environmental	Liquid pouring [210]					
External capital	Clients per number of employees [211]					
External capital	% Utility [151]					
External capital	Utility per new client [151]					
External capital	Number of lost clients [151]					

Type of indicator	Indicator	Mark with an X if you use the indicator	Value or base value of the indicator considered normal	Range of the indicator considered deficient	Range of the indicator considered excellent	Observation
External capital	Number of bills, real clients [151]					
External capital	% of participation in the market [151]					
External capital	% of client satisfaction [211]					
External capital	Income ($) [151]					
Human capital	Motivation index [211]					
Human capital	Average years in service to the company [211]					
Human capital	Training expenses per employee [211]					
Human capital	Number of days per years in training [211]					
Human capital	Number of employees [211]					
Human capital	Number of full-time					

Type of indicator	Indicator	Mark with an X if you use the indicator	Value or base value of the indicator considered normal	Range of the indicator considered deficient	Range of the indicator considered excellent	Observation
	employees [211]					
Human capital	Number of area chiefs [209, 211]					
Human capital	Number of female chiefs [211]					
Human capital	Number of staff members [211]					Then, it would measure the departments as well.
Human capital	Number of employees with higher education (Master´s degree or doctorate) [211]					What is advanced?, I think is better to identify professional, master's degree or doctorate
Human capital	Percentage of leaders [211]					What is a leader?
Human capital	Percentage of personnel rotation [211]					
Human capital	Average age of the full-time employees [211]					
Human capital	Aggregate value per					What is aggregate value?, is it income?

Type of indicator	Indicator	Mark with an X if you use the indicator	Value or base value of the indicator considered normal	Range of the indicator considered deficient	Range of the indicator considered excellent	Observation
	employee ($) [211]					
Internal capital	Computers per employee [211]					Investment in technology/employee?, what is the objective of this?, could applications of management and collaborations be identified?
Internal capital	% cost of error or re-processes within the incomes [151]					Errors, does it refer to defective products?, pig deaths? The indicator is not understood The global re-processes
Internal capital	% Depreciation of IT among the total IT inventory [211]					
Internal capital	% administrative expenses within the income [151]					
Internal capital	% IT expenses over the expenses					

Type of indicator	Indicator	Mark with an X if you use the indicator	Value or base value of the indicator considered normal	Range of the indicator considered deficient	Range of the indicator considered excellent	Observation
	[211]					
Internal capital	IT inventory ($) [211]					
Internal capital	% IT Staff among total staff [211]					
Internal capital	Time of process in payments [151]					
Internal capital	Sales per employee ($) [151]					
Internal capital	Investment in research and development ($)					
Financial	**Cost per Kg produced** ($) [151]					
Financial	**Income per Kg produced** ($) [151]					
Financial	Cost per kg ($) [151]					
Financial	Ebitda (%) [151]					

More indicators: Please mention what other indicators you know or would like to measure within the swine supply chain

Other indicators proposed	Other indicators proposed

Interest of the respondent for the project:

- Relating to the management indicators applied to your company, what do you use them for?

  _____
  _____

  _____
  _____

  _____
  _____

- Does your company use global or phased control boards?

  _____
  _____

- What type of actions do you make considering the results of the management indicators?

_____

_____

_____
_____

- Would you like to have a free web application, where you could measure and share the previously mentioned management indicators? **Yes**__ **No**___

- Would you like to have a free public platform where you could find information of your interest about Colombian companies working within the swine supply chain? **Yes**__ **No**___

- Would you be willing to share the information generated by your company in a public platform oriented towards the knowledge of the swine supply chain? **Yes**__ **No**___

- Do you belong to any community or platform that gives information of interest in the swine supply chain? **Yes**__ **No**___

  ¿Which one? _____

- Would you like to be an active member of this project, receive visits, share information and know about the results of the research? **Yes**__ **No**___

- Aside of the information about the management indicators mentioned before, what other type of information would you like to see through the application in the platform?

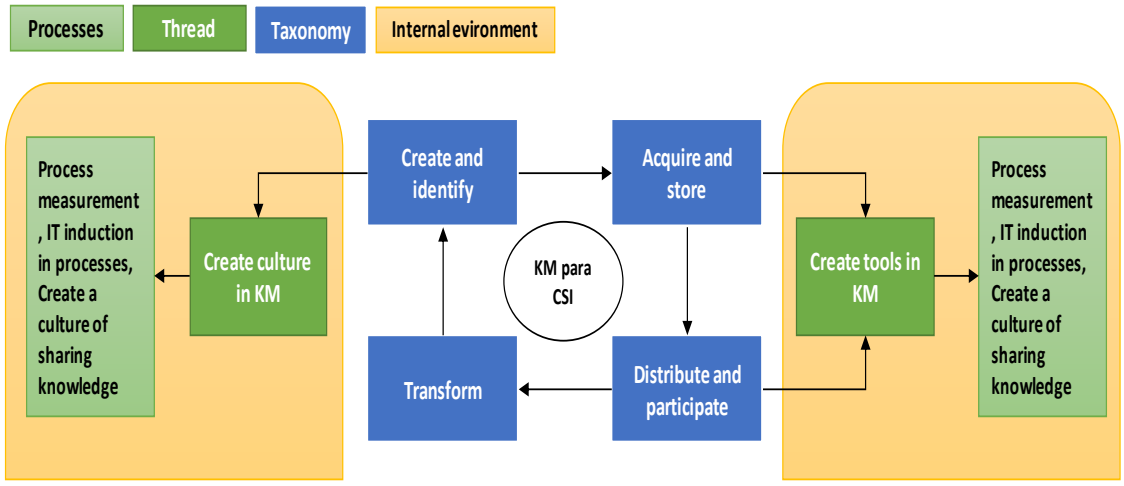
Other topics of interest to publish in the application

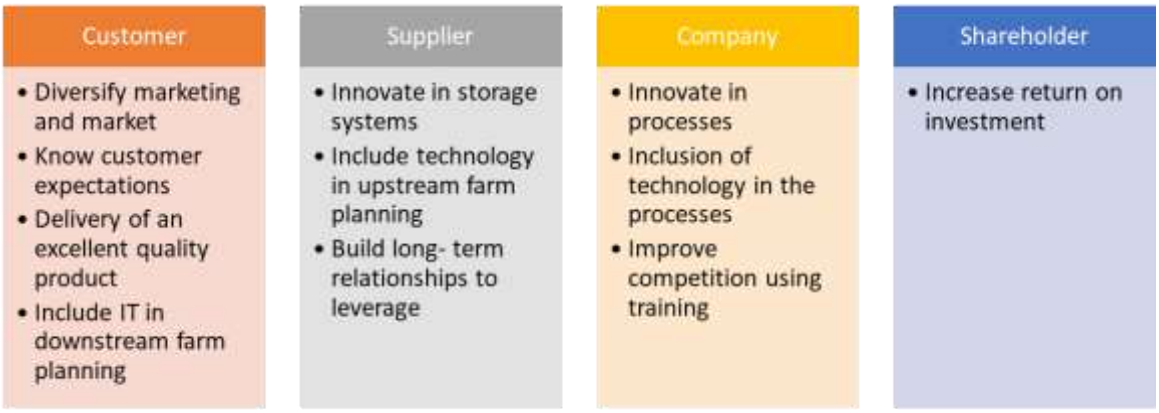
12.2 ANNEX 2. VALIDATION OF THE KNOWLEDGE MANAGEMENT (KM) MODEL FOR THE COLOMBIAN SWINE INDUSTRY (CSI) IN THE ANDINA REGION.

The Knowledge Management (KM) was born in 1975 with [152-154] with the classical theories of [110, 155-158]; most studies in the literature are applied at the organizational level, and not in sectors. Knowledge management (KM) is connected to the concept of the knowledge economy, which seeks to increase the profitability, innovation capacity and knowledge transfer of actors [159]. KM is a set of processes and tools to manage and capitalize on people's knowledge and good practices that lead to competitiveness [160, 161],

Taking into account the above, in the master's project entitled “Design of a knowledge management model for the swine supply chain in the Colombian Andean region using a Balanced Scorecard tool”. A KM model is proposed to encourage the improvement of the SSC indicators in the Andean region. To validate this KM model, the option of expert validation is chosen, taking into account its possibility of immediate application [203].

The proposed model consists of 4 phases:





- **The first phase is to create and identify knowledge:** This phase identifies the strengths, potential and opportunities of the local environment that are available to the actors, efficiencies of the local production system, composition and variety of processes, products and services. offered, everything that provides knowledge and contribution to the CSI [199].

  His first phase seeks to identify within the pig farms what is the valid knowledge for the CSI both at the level of customers, suppliers, company (internal knowledge) and shareholders.

  For this phase, we proceeded to document each of the breeding and fattening processes for the Colombian Swine Industry (CSI): Gestation, lactation, pre-fattening and fattening. Identifying each of the activities within each and the critical information of each process. Additionally, a review of the literature was carried out to identify which are the most appropriate indicators for the CSI, these were validated through a survey carried out with the actors of the CSI in the Andina zone of Colombia.

5. **The second phase is acquiring and storing knowledge:** In this phase it is necessary to differentiate between the existing knowledge of actors or organizations that have a cultural, organizational or relational heritage that contributes to agricultural development and knowledge that exists outside either in universities , other sites or countries or research centers. To later define how and where it is stored and how it is consulted, preferably through a technological system [199].

The measurement of indicators potentiates GC towards processes, adding value, capacity for innovation [106]. Therefore, in this phase we proceeded to design a measurement instrument called Balanced Scorecard (BSC), it was determined within the investigation that the IPC is a highly polluting industry in the environment, so based on the literature it was proposed to add to the BSC a fifth

sustainable perspective that was transversal to the others, which allows the IPC to systematically measure the environmental and social impact of its activity, this resulted in an instrument called Sustainable Scorcard Balance (BSCS). Only four indicators were established since having too many indicators can cause confusion and divert attention from the main strategy, taking into account that it is a very informal sector and without a measurement culture [76]. The suggested indicators were taken taking the survey applied to the CSI stakeholders..

The BSCS is made up of the following perspectives:

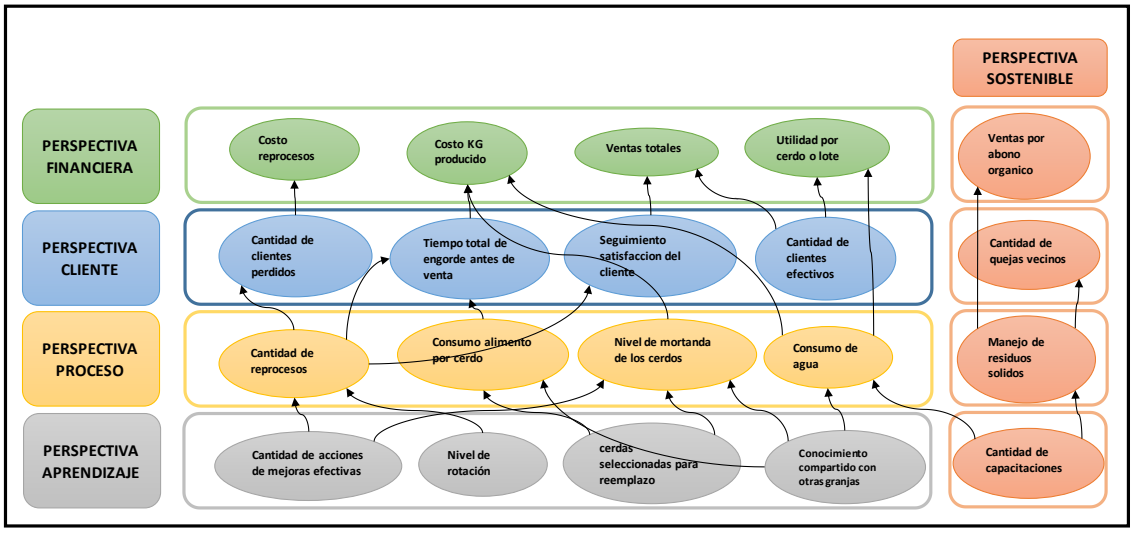
Financial Perspective: quantitatively measured and considered extremely important in the business world [73, 79]. Within pig farms it will allow to measure the financial health of the farm, they are the main indicators for managers and shareholders.

Customer Perspective: it can be seen from the point of view; products or services provided, satisfaction of the community in the quality of the service provided, complaints or complaints from the community as a direct user, capacity in the service most required by the community [76, 83]. It will allow you to measure customers on the farm, how customers view the farm and what level of satisfaction they have with the products and care provided by the farm.

Process Perspective: focuses on the competencies of the central management processes within the company [76, 79]. It focuses on measuring the activities of the CORE processes of the farm such as pregnancy, lactation, pre-fattening and fattening, providing information for decision-making.

Learning perspective: it can be seen from the point of view; measure factors related to technology, staff development, systems and procedures, and other factors that need to be updated [73, 83]. Allowing the farm to develop from a technological and human resource point of view.

Sustainable Perspective: It allows to measure environmental and social impacts [76]. Allowing the farm to assess environmental impacts and to make a useful use of farm waste.



- **The third phase is to distribute and share knowledge:** This phase uses efficiently and effectively all the means of communication available in written, oral or electronic form; individual, local or network to make information for decision-making available to all actors. The appropriation and safekeeping and custody of this knowledge by the people or companies that receive it must also be guaranteed [199].

  In this phase it is necessary to make the BSCS known to the entire farm so that each of the active members within the processes knows their objective and purpose, helping to mature the indicators and improving the strategies that lead the farm to meet the objectives. , documenting each of the actions. In order to generate a common benefit within the IPC, these strategic plans or successful actions must be public within the IPC actors, as well as the failed strategies or actions to avoid reproducing errors. The exchange of information and knowledge at the intra and inter-organizational level should be promoted [162], generating job and academic training programs [163], and attracting qualified personnel to enhance the CSI [164, 165].

- **The fourth phase is to transform knowledge**: This phase can be defined as the action of taking knowledge to a second evolutionary phase, taking existing knowledge, applying it, and from this application obtaining new or transformed knowledge [200].

  In this last phase, continuous improvement is sought within the IPC, where its actors must generate more and better knowledge of the indicators and strategies proposed.

VALIDATION INSTRUMENT:

An instrument is built to evaluate the proposed KM model from 4 categories: Clarity, coherence, relevance and sufficiency [212]. These categories apply one by one to a broader concept which are the phases of the QA model which we will call “Dimensions” [203]. For the election of the judges, it was determined to have 3 judges or experts that include 2 people who are knowledgeable on the subject taking into account their academic background and 2 people who are knowledgeable on the subject taking into account their work experience, as recommended [203, 212]

Expert Name:	
Company where you work:	
Actual charge:	
Academic profile:	
Work experience:	
Email:	

According to the following categories (Sufficiency, clarity, coherence and relevance) rate each of the questions from 1 to 5 taking into account your knowledge and experience in each of the topics. Keep in mind that you must use a five-point Likert scale where: 5 indicates (Very High); 4 indicates (High); 3 Indicates (Does not know - Does not respond); 2 indicates (low) and 1 indicates (Very low).

DIMENSIONS	CATEGORIES	QUESTIONS	QUALIFICATION				
			1	2	3	4	5
Create and identify knowledge	**Sufficiency**	¿At what level of competence do you consider that the QA model complies by proposing to identify knowledge through the customers, suppliers, the company and the shareholders of the CSI in the Colombian Andean zone?					
	Clarity	¿What is the level of understanding within the KM model of the role of the clients, suppliers, the company and the CSI shareholders in the Colombian Andean zone?					

DIMENSIONS	CATEGORIES	QUESTIONS	QUALIFICATION				
			1	2	3	4	5
	Coherence	¿What level of relationship do customers, suppliers, the company and shareholders have in the phase of creating and identifying knowledge within the proposed QA model?					
	Relevance	¿How significant is it to involve external actors such as Customers, Suppliers and Actions in the phase of creating and identifying the proposed KM model?					
Store and acquire knowledge	**Sufficiency**	¿What level of capacity does the proposal to have 4 indicators per perspective consider within the BSCS for the Store phase and acquire knowledge of the proposed KM model??					
	Clarity	¿What level of assimilation has the sustainable perspective and its indicators within the BSCS that contains the proposed KM model?					
	Coherence	¿What level of connection does the BSCS have with the proposed KM model?					
	Relevance	¿How important do you consider it is to have a BSCS tool within the process of storing and acquiring knowledge for the proposed KM model??					
Distribute and share knowledge	**Sufficiency**	¿Considers that the focus of this phase towards the sub-processes of distributing and sharing knowledge among the CSI actors in the Colombian Andean zone is complete within the KM model?					

DIMENSIONS	CATEGORIES	QUESTIONS	QUALIFICATION				
			1	2	3	4	5
	Clarity	¿How understandable is the proposal to exchange information and knowledge at an intra and inter-organizational level within the proposed KM model?					
	Coherence	¿How consistent do you consider the proposed strategy to be to exchange information and knowledge at the intra and inter-organizational level strengthens the sharing of knowledge?					
	Relevance	¿How fundamental is the strategy proposed on sharing or making knowledge public among each of the CIS actors in the Colombian Andean zone to strengthen the distribution of knowledge?					
Transform knowledge	**Sufficiency**	¿How apt do you consider the proposal to transform knowledge within the proposed KM model?					
	Clarity	¿How assimilable is the phase of transforming knowledge within the KM model?					
	Coherence	¿How much connection does the phase of transforming knowledge consider with the rest of the phases proposed in the proposed KM model?					
	Relevance	¿At what level do you consider that the QA model meets what is necessary to transform existing knowledge into new knowledge?					

Other open questions:

- ¿Do you consider, based on your experience and / or knowledge, that some of the indicators within the perspectives of the BSCS proposed in this model should be deleted or omitted??

No: __
Yes: ___
Please relate which, in which perspective and ¿why? _____

- ¿Do you consider, based on your experience and / or knowledge, that other indicators should be added within the perspectives of the BSCS proposed in this project?

No: __
Yes: ___
Please relate which, in which perspective and ¿why?_____

- ¿Do you consider based on your experience and / or knowledge that the proposed knowledge management model lacks elements to take into account?

No: __
Yes: ___
Please list which and why: _____

- ¿Based on your experience and / or knowledge, you can make a recommendation or contribution that you consider important for the project?

No: __
Yes: ___
Please list which: _____

- ¿Do you Consider that the validation instrument contains clear and precise instructions to answer the questionnaire?

No: __
No: ___
Please mention why: _____

Expert Signature

13. BIBLIOGRAPHIC REFERENCES

[1] Porkcolombia. (2019, 01 JUNE 2019). *Boletin Economico Abril 2019*. Available: https://www.miporkcolombia.co/wp-content/uploads/2019/05/Bol_Abril_19.pdf

[2] Porkcolombia. (2019, 01 JUNE 2019). *ANÁLISIS DE COYUNTURA DEL SECTOR PORCICULTOR DEL AÑO 2018 Y PERSPECTIVAS 2019*. Available: https://www.miporkcolombia.co/wp-content/uploads/2019/03/Bol_Inf_2018.pdf

[3] I. T. map. (2019, April 22, 2019). *Trade statistics for international business development*
Monthly, quarterly and yearly trade data. Import & export values, volumes, growth rates, market shares, etc
Available: https://www.trademap.org/Country_SelProductCountry_Graph.aspx?nvpm=1%7c170%7c%7c%7c%7c0203%7c%7c%7c4%7c1%7c1%7c1%7c1%7c%7c2%7c1%7c1

[4] DANE. (2018, August 22, 2018). *Boletín técnico - Producto Interno Bruto*. Available: https://www.dane.gov.co/files/investigaciones/boletines/pib/bol_PIB_IItrim18_producion_y_gasto.pdf

[5] DANE. (2018, August 22). *Cuentas Trimestrales - Colombia Producto Interno Bruto (PIB): Primer Trimestre de 2015*. Available: http://www.dane.gov.co/index.php/52-espanol/noticias/noticias/4174-producto-interno-bruto-pib-i-trimestre-2017

[6] SAC. (2018, August 22, 2018). *Estadísticas > Producción Agropecuaria desde 2000 > Producción pecuaria*. Available: http://sac.org.co/es/estudios-economicos/estadisticas.html

[7] BM. (2018, August 22). *Indicadores > Agricultura, valor agregado (% del PIB) Colombia (Banco Mundial ed.)*. Available: https://datos.bancomundial.org/indicador/NV.AGR.TOTL.ZS?locations=CO

[8] DANE. (2013, Junio 28). *Cuenta Satélite Piloto de la Agroindustria (CSPA): Procesos de cría de ganado bovino y porcino y su primer nivel de transformación industrial (Resultados preliminares 2005 – 2011)*. Available: https://www.dane.gov.co/files/investigaciones/pib/agroindustria/metodologia_CSPA_Ganado_bovino_porcino_23_2013.pdf

[9] DANE. (2019, March 18, 2019). *Encuesta de sacrificio de ganado (ESAG)*. Available: https://www.dane.gov.co/index.php/estadisticas-por-tema/agropecuario/encuesta-de-sacrificio-de-ganado

[10] Porkcolombia. (2019, February 2019). *Costos*. Available: https://www.miporkcolombia.co/cifras/costos/

[11] C. A. Ronderos & Cárdenas. (2010, June 25, 2015). *Sector Porcícola en Colombia*. Available: http://ronderosycardenas.com/ActualidadRyC/Inf.Ejec.PorkCol./
[12] MinAgricultura. (2018). *Cadena carnica porcina*. Available: https://sioc.minagricultura.gov.co/Porcina/Documentos/002%20-%20Cifras%20Sectoriales/002%20-%20Cifras%20Sectoriales%20-%202018%20Enero%20C%C3%A1rnica%20Porcina.pdf
[13] DANE. (2018, August 20, 2018). *Tercer Censo Nacional Agropecuario (Departamento Administrativo Nacional de Estadística (DANE) ed.)*. Available: https://www.dane.gov.co/files/images/foros/foro-de-entrega-de-resultados-y-cierre-3-censo-nacional-agropecuario/CNATomo2-Resultados.pdf
[14] DANE. (2014, August 20, 2018). *Tercer Censo Nacional Agropecuario (Departamento Administrativo Nacional de Estadística (DANE) ed.)*. Available: https://www.dane.gov.co/index.php/estadisticas-por-tema/agropecuario/censo-nacional-agropecuario-2014
[15] MinAgricultura. (2015, August 24). *Capítulo 12 - Decreto 1648 de 2015 (Ministerio de Agricultura y Desarrollo Rural ed.)*. Available: https://www.minagricultura.gov.co/Normatividad/Paginas/Decreto-1071-2015/CAPITULO-12-Fondo-Nacional-de-la-Porcicultura.aspx
[16] Porkcolombia. (2018, August 25). *Análisis de coyuntura del sector porcicultor primer semestre 2018*. Available: http://miporkcolombia.co/cifras/boletines-economicos/
[17] DANE. (2018, August 25). *Encuesta de sacrificio de ganado (ESAG)*. Available: http://www.dane.gov.co/index.php/estadisticas-por-tema/pobreza-y-condiciones-de-vida/encuesta-nacional-del-uso-del-tiempo-enut?id=131&phpMyAdmin=3om27vamm65hhkhrtgc8rrn2g4
[18] PorkColombia. (2018, August 27, 2018). *Análisis de conyuntura del sector porcicultor Primer Semestre del 2018*. Available: http://miporkcolombia.co/wp-content/uploads/2018/08/Bol_Inf_2018_01.pdf
[19] A. Z. Mazo, R. A. G. Montoya, and S. A. F. Henao, "Indicadores logísticos en la cadena de suministro como apoyo al modelo scor," *Clío América,* vol. 8, pp. 90-110, 2014.
[20] A. Salgueiro, *Indicadores de gestión y cuadro de mando*: Ediciones Díaz de Santos, 2001.
[21] C. de Mando Integral, "Robert S. Kaplan y David P," ed: Norton Ediciones Gestión, 2000.
[22] M. O. Enríquez, "Gestión de Información de Producción Porcina en Pie, Toma de Decisiones Soportada en Metodologías Blandas," *Scientia et technica,* vol. 23, pp. 359-368, 2018.
[23] M. E. Porter, *Competitive advantage of nations: creating and sustaining superior performance* vol. 2: Simon and Schuster, 2011.
[24] CCB, *Creación de la ventaja competitiva para Colombia: patrones de competitividad y análisis sectorial, resumén de los estudios realizados por la firma monitor*: Cámara de Comercio, 1994.

[25] iNNpulsa and CD. (2018). *Iniciativas Clúster en Colombia*. *1*. Available: https://www.innpulsacolombia.com/sites/default/files/libro_iniciativas_cluster_en_colombia.pdf
[26] DNP. (2015, August 11, 2018). *Rutas para la asociatividad rural en Colombia*. Available: https://www.dnp.gov.co/programas/agricultura/Paginas/Rutas-para-la-asociatividad-rural-en-Colombia.aspx
[27] M. Reina and F. Castro, "20 años de políticas de competitividad en Colombia," 2013.
[28] MinComercio, DNP, Bancoldex, and Proexport. (1999, Política para la productividad y la competitividad. Available: http://www.mincit.gov.co/loader.php?lServicio=Documentos&lFuncion=verPdf&id=48506&name=politicaprodycompjul17-99.pdf&prefijo=file
[29] SIOC. (2011, June 29). *Sector Porcícola*. Available: http://sioc.minagricultura.gov.co/templates/sioc_cadenas/docs/1150.pdf
[30] iNNpulsa. (August 18, 2018). *Nuestra Organizacion >Quienes somos*. Available: https://www.innpulsacolombia.com/es/nuestra-organizacion
[31] Porkcolombia. (2019, 15 marzo 2019). *ANÁLISIS DE COYUNTURA DEL SECTOR
PORCICULTOR DEL AÑO 2018 Y
PERSPECTIVAS 2019*. Available: https://www.miporkcolombia.co/wp-content/uploads/2019/03/Bol_Inf_2018.pdf
[32] FAO. (August 24). *Producción pecuaria en América Latina y el Caribe*. Available: http://www.fao.org/americas/prioridades/produccion-pecuaria/es/
[33] I. M. Aportela-Rodríguez and G. Ponjuán-Dante, "La Segunda Generación de la Gestión del Conocimiento: un nuevo enfoque de la gestión del conocimiento," *Ciencias de la Información,* vol. 39, pp. 19-30, 2008.
[34] J. F. E. García, *Sistema de indicadores para el diagnóstico y seguimiento de la educación superior en México*: ANUIES, 2007.
[35] J. H. B. Lozano, "Construcción de indicadores de gestión bajo el enfoque de sistemas," 2003.
[36] L. Bonet Agustí and E. C. Rodríguez Taylor, "Guía para la construcción de indicadores de gestión," 2012.
[37] F. N. A. Santana, "Tablero de Control para entidades orientadas a proyecto," Tesis de Maestría, Universidad de las Ciencias Informáticas, Cuba, 2015.
[38] K. Bradley, "Intellectual capital and the new wealth of nations II," *Business Strategy Review,* vol. 8, pp. 33-44, 1997.
[39] A. Brooking and J. C. Guix, *El capital intelectual*: Paidós Barcelona, 1997.
[40] N. Alomoto, C. Acuña, M. Salvador, J. Ortíz, and A. Ruiz, "La gestión de la cadena de suministro en Ecuador: caso de las PYMES," *Revista Arbitrada Formación Gerencial,* vol. 13, 2015.
[41] R. S. Kaplan and D. P. Norton, *Cuadro de mando integral: the Balanced Scorecard*: Gestión 2000, 2002.

[42] M. Kuncová, V. Hedija, and R. Fiala, "Firm size as a determinant of firm performance: The case of swine raising," *Agris on-line Papers in Economics and Informatics,* vol. 8, pp. 77-89, 2016.
[43] P. Chytas, M. Glykas, and G. Valiris, "A proactive balanced scorecard," *International Journal of Information Management,* vol. 31, pp. 460-468, 2011.
[44] Ľ. Lesáková and K. Dubcová, "Knowledge and use of the balanced scorecard method in the businesses in the Slovak Republic," *Procedia-Social and Behavioral Sciences,* vol. 230, pp. 39-48, 2016.
[45] G. d. mexico. (2019, March 13, 2019). *Secretaría de Agricultura y Desarrollo Rural*. Available: https://www.gob.mx/sader/articulos/que-es-la-porcicultura
[46] J. M. Denolf, J. H. Trienekens, P. N. Wognum, V. Schütz, J. G. Van Der Vorst, and S. O. Omta, "“Actionable” critical success factors for supply chain information system implementations," *International Journal on Food System Dynamics,* vol. 9, 2018.
[47] K. Zhang, Y. Chai, D. Weng, and R. Zhai, "Analysis and design of information traceability system for pork production supply chain," *Transactions of the Chinese Society of Agricultural Engineering,* vol. 26, pp. 332-339, 2010.
[48] N. Wognum and M. Wever, "Quality and co-ordination in supply chains—The case of pork chains in the Netherlands," in *2008 IEEE International Technology Management Conference (ICE)*, 2008, pp. 1-8.
[49] E. F. da Silva, F. C. M. Pereira, and E. H. G. Rodrigues, "Creation of Organizational Knowledge on the Basis Von Krogh, Nonaka and Ichijo Capacitors: A Case Study in the Grange Df Pork Company," *International Journal of Innovation: IJI Journal,* vol. 4, pp. 155-172, 2016.
[50] M. J. P. da Costa, S. M. Huertas, C. Gallo, and O. A. Dalla Costa, "Strategies to promote farm animal welfare in Latin America and their effects on carcass and meat quality traits," *Meat Science,* vol. 92, pp. 221-226, 2012.
[51] E. Errea, M. I. Ruiz, G. Souto, E. Errea, M. I. Ruiz, and G. Souto, "CADENA PORCINA: Análisis de competitividad y temas tecnológicos prioritarios," *INIA, Informe de consultaría, 92p,* 2013.
[52] S. H. G. José Elías Jiménez Sánchez, "Marco conceptual de la cadena de suministro: un nuevo enfoque logístico," vol. 125, p. 272, 2002.
[53] ASPROCER. (2019, April 30, 2019). *Asociacion gremial de productores de cerdo de Chile*. Available: https://www.asprocer.cl/industria/analisis-sectorial/
[54] E. J. R. Moore, "Evaluación de un sistema intensivo de producción de cerdos en la localidad de Río Bueno, Región de Los Ríos. Estudio de Caso," Universidad Austral de Chile, 2017.
[55] E. Errea, M. I. Ruiz, and G. Souto, "Cadena Porcina: análisis de competitividad y temas tecnológicos prioritarios: Informe de Consultoría," 9974383579, 2013.

[56] R. Fajardo, "Plaza Colombia: modelo de negocio para la creación de ventajas competitivas utilizando tecnologías de información en el sector agrícola," Universidad de La Sabana, 2018.
[57] O. J. Morelo Ayazo and J. D. Viloria Arteaga, "Diseño e implementación de una aplicación para dispositivos móviles que permite la automatización de un sistema para el suministro de alimento de porcinos bajo la plataforma Android," 2018.
[58] C. P. Uribe Galvis, S. L. Fonseca Rodríguez, G. E. Bernal Ramos, C. A. Contreras Pedraza, and Ó. F. Castellanos Domínguez, "Sembrando innovación para la competitividad del sector agropecuario colombiano," ed: Ministerio de Agricultura y Desarrollo Rural; Universidad Nacional de Colombia, 2011.
[59] M. d. a. y. desarrollo, "AGENDA DE INVESTIGACIÓN Y DESARROLLO TECNOLÓGICO PARA LA CADENA CÁRNICA PORCINA," 2011 2011.
[60] 3tres3. (2019, March 11, 2019). *3tres3*. Available: https://www.3tres3.com/
[61] Agritec. (2019). *Porcitec*. Available: https://www.agritecsoft.com/porcitec/es/
[62] G. online. (2019). *Porci Control*. Available: https://www.ganaderosonline.com
[63] p. p. europa. (2019). *pigchamp*. Available: https://www.pigchamp-pro.com/es/
[64] C. online. (2019). *Criaderos online*. Available: http://criaderosonline.com.ar/
[65] S. p. italia. (2019). *InControl Porcinos*. Available: https://www.softpi.com/es/software-incontrol-porcinos-cerdos/
[66] M. T. d. Alvear. (2019). *Infopork*. Available: https://infopork.com/2012/05/desarrollo-de-un-software-para-el-registro-de-la-producci-n-porcina/
[67] S. S. p. porcinos. (2019). *Suinowebs*. Available: http://www.suinowebs.com/interna-epremium.php
[68] Apps.co. (2019). *Softporc*. Available: https://apps.co/cuentas/perfil/96756/asesppo/
[69] Pigwin. (2019). *Pigwin*. Available: http://www.pigwin.com/home/
[70] Zooeasy. (2019). *Zooeasy*. Available: https://www.zooeasy.com
[71] Bayer. (2019). *Animal Health*. Available: https://animalhealth.bayer.com/sowdition
[72] MinAmbiente. (2019, May 6, 2019). *Miniestrio de Ambiente y Desarrollo Sostenible*. Available: http://www.minambiente.gov.co/index.php/normativa/leyes
[73] H.-C. Huang, "Designing a knowledge-based system for strategic planning: A balanced scorecard perspective," *Expert Systems with Applications,* vol. 36, pp. 209-218, 2009.
[74] M. Casas, M. Perez, J. Rojas, and J. Alvarez, "Strategic Planning Model to Improve Competitiveness for Service Industry SMEs Using the Balanced Scorecard," in *International Conference on Human Interaction and Emerging Technologies*, 2019, pp. 1001-1006.

[75] K. Zeng and X. Luo, "The balanced scorecard in China: Does it work?," *Business Horizons,* vol. 56, pp. 611-620, 2013.
[76] Z. T. Kalender and Ö. Vayvay, "The fifth pillar of the balanced scorecard: Sustainability," *Procedia-Social and Behavioral Sciences,* vol. 235, pp. 76-83, 2016.
[77] J. A. Moraga, L. E. Quezada, P. I. Palominos, A. M. Oddershede, and H. A. Silva, "A quantitative methodology to enhance a strategy map," *International Journal of Production Economics,* vol. 219, pp. 43-53, 2020.
[78] Y. Hu, S. Xiao, J. Wen, and J. Li, "An ANP-multi-criteria-based methodology to construct maintenance networks for agricultural machinery cluster in a balanced scorecard context," *Computers and electronics in agriculture,* vol. 158, pp. 1-10, 2019.
[79] J. K. Myung, H.-T. An, and S.-Y. Lee, "Corporate Competitiveness Index of Climate Change: A Balanced Scorecard Approach," *Sustainability,* vol. 11, p. 1445, 2019.
[80] G. Manville, F. Karakas, M. Polkinghorne, and N. Petford, "Supporting open innovation with the use of a balanced scorecard approach: a study on deep smarts and effective knowledge transfer to SMEs," *Production Planning & Control,* vol. 30, pp. 842-853, 2019.
[81] H. B. Harvey and S. T. Sotardi, "Key performance indicators and the balanced scorecard," *Journal of the American College of Radiology,* vol. 15, pp. 1000-1001, 2018.
[82] Y. K. Teniwut, "Decision support system for increasing sustainable productivity on fishery agroindustry supply chain," in *2013 International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, 2013, pp. 297-302.
[83] I. Muda, I. Y. Erlina, and N. AA, "Performance Audit and Balanced Scorecard Perspective," *International Journal of Civil Engineering and Technology,* vol. 9, pp. 1321-1333, 2018.
[84] L. Valenzuela and S. Maturana, "Designing a three-dimensional performance measurement system (SMD3D) for the wine industry: A Chilean example," *Agricultural Systems,* vol. 142, pp. 112-121, 2016.
[85] H. C. Oliveira, L. Lima-Rodrigues, and R. Craig, "The presence of bureaucracy in the balanced scorecard," *Revista de Contabilidad-Spanish Accounting Review,* vol. 22, pp. 218-224, 2019.
[86] S. S. Al-Qubaisi and M. Ajmal, "Determinants of operational efficiency in the oil and gas sector: A Balanced scorecards perspective," *Benchmarking: An International Journal,* vol. 25, pp. 3357-3385, 2018.
[87] P. Chong, T. Ong, A. Abdullah, and W. Choo, "Internationalisation and innovation on balanced scorecard (BSC) among Malaysian small and medium enterprises (SMEs)," *Management Science Letters,* vol. 9, pp. 1617-1632, 2019.
[88] R. Gibbons and R. S. Kaplan, "Formal measures in informal management: can a balanced scorecard change a culture?," *American Economic Review,* vol. 105, pp. 447-51, 2015.

[89] M. Peris-Ortiz, D. García-Hurtado, and C. Devece, "Influence of the balanced scorecard on the science and innovation performance of Latin American universities," *Knowledge Management Research & Practice,* pp. 1-11, 2019.
[90] L. Loayza, S. Olave, M. Perez, J. Rojas, and C. Raymundo, "Management Model Based on the Lean Thinking Method for Medium-Sized Peruvian Companies in the Apparel Sector," in *International Conference on Human Interaction and Emerging Technologies*, 2019, pp. 896-902.
[91] E. B. Leksono, S. Suparno, and I. Vanany, "Integration of a Balanced Scorecard, DEMATEL, and ANP for Measuring the Performance of a Sustainable Healthcare Supply Chain," *Sustainability,* vol. 11, p. 3626, 2019.
[92] I. Hristov, A. Chirico, and A. Appolloni, "Sustainability Value Creation, Survival, and Growth of the Company: A Critical Perspective in the Sustainability Balanced Scorecard (SBSC)," *Sustainability,* vol. 11, p. 2119, 2019.
[93] A. Chiran, E. Gîndu, G. Ungureanu, B. Drobotă, and A. F. Jităreanu, "Designing an informatics' system regarding the technical-economic and financial analysis of integrated agro alimentary units," in *15th International Business Information Management Association Conference, IBIMA 2010*, Cairo, 2010, pp. 1160-1165.
[94] D. J. Kurtz, E. J. S. Sierra, and G. Varvakis, "LCA application in Brazilian electric mix: A multi-scenario analysis in terms of climate change, ecosystem quality, human health and resources," *Espacios,* vol. 34, 2013.
[95] E. F. da Silva, F. C. Mafra Pereira, and E. H. Guimaraes Rodrigues, "Creation of organizational knowledge on the basis Von Krogh, Nonaka and Ichijo capacitors: a case study in the grange DF Pork Company," *International Journal of Innovation,* vol. 4, pp. 155-172, Jul-Dec 2016.
[96] K. Zhang, Y. Chai, D. Weng, and R. Zhai, "Analysis and design of information traceability system for pork production supply chain," *Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering,* vol. 26, pp. 332-339, 2010.
[97] M. L. Nogueira and N. P. Greis, "An Answer Set Programming Solution for Supply Chain Traceability," in *4th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management, IC3K 2012* vol. 415, ed. Barcelona: Springer Verlag, 2013, pp. 211-227.
[98] N. Wognum and M. Wever, "Quality and co-ordination in supply chains - The case of pork chains in the Netherlands," in *IEEE International Technology Management Conference, ICE 2008*, 2016.
[99] M. J. R. Paranhos da Costa, S. M. Huertas, C. Gallo, and O. A. Dalla Costa, "Strategies to promote farm animal welfare in Latin America and their effects on carcass and meat quality traits," *Meat Science,* vol. 92, pp. 221-226, 2012.

[100] G. Selva, "Analysis of the Competitiveness of the Pork Industry in Denmark," in *99th seminar of the EAAE "The Future of Rural Europe in the Global Agri-Food System", Copenhagen, denmark, August*, 2005, pp. 24-27.
[101] AHDB and BPEX. (2011, Profitability in the Pig Supply Chain. Available: https://pork.ahdb.org.uk/media/2338/profitability_in_the_pig_supply_chain.pdf
[102] B. Duflot, M. Roussillon, and M. Rieu, "A competitiveness index for national pork chains in Europe: for the years 2010, 2011 and 2012," *Cahiers de l'IFIP,* vol. 1, pp. 29-45, 2014.
[103] J. Trujillo-Diaz, F. N. Diaz-Piraquive, M. M. Herrera, and J. Gomez, "Modeling the Colombian Swine Supply Chain from a Knowledge Management Perspective," *International Journal of Web Engineering and Technology,* vol. 28, pp. 1-12, 2019.
[104] R. Hernández Sampieri, C. Fernández Collado, and P. Baptista Lucio, *Metodología de la investigación* vol. 3: México: McGraw-Hill, 2010.
[105] R. Sampieri Hernández, C. Fernandez Collado, and M. d. P. Baptista Lucio, *Metodología de la Investigación*, 6th edition ed. México: MrGraw-Hill, 2014.
[106] W. Peng Wong and K. Yew Wong, "Supply chain management, knowledge management capability, and their linkages towards firm performance," *Business Process Management Journal,* vol. 17, pp. 940-964, 2011.
[107] G. Paixão, A. Esteves, and R. Payan-Carreira, "Characterization of a non-industrial pig production system: the case of Bísaro breed," *Revista Brasileira de Zootecnia,* vol. 47, 2018.
[108] K. R. Kithinji, T. I. Kanui, A. J. Ndathi, and R. M. Mwobobia, "Characterization of pig production systems in Embu west sub county, Embu County, Kenya," 2017.
[109] N. Ieda, Q. Van Bui, N. T. D. Nguyen, L. Lapar, and K. Marshall, "Characterization of smallholder pig breeding practices within a rural commune of North Central Vietnam," *Tropical animal health and production,* vol. 47, pp. 1005-1016, 2015.
[110] B. Kogut and U. Zander, "Knowledge of the firm, combinative capabilities, and the replication of technology," *Organization science,* vol. 3, pp. 383-397, 1992.
[111] G. M. M. A. Gawad, T. T. Alkhteeb, and M. T. Intezar, "Determinants of competitive advantages of dates exporting: An applied study on Saudi Arabia," *International Journal of Economics and Finance,* vol. 6, p. 79, 2014.
[112] E. Molendowski and M. Żmuda, "Changes in competitiveness among the Visegrad countries after accession to the European Union: A comparative analysis based on a generalized double diamond model," *Comparative Economic Research,* vol. 16, pp. 121-153, 2013.
[113] B. Jin and H.-C. Moon, "The diamond approach to the competitiveness of Korea's apparel industry: Michael Porter and beyond," *Journal of Fashion Marketing and Management: An International Journal,* vol. 10, pp. 195-208, 2006.

[114] M. Sardy and M. Fetscherin, "A double diamond comparison of the automotive industry of China, India, and South Korea," 2009.
[115] H.-C. Moon and D. Lee, "The competitiveness of multinational firms: A case study of Samsung Electronics and Sony," *Journal of International and Area Studies,* pp. 1-21, 2004.
[116] P. Patichol, W. Wongsurawat, and L. M. Johri, "Upgrade strategies in the Thai silk industry: balancing value promotion and cultural heritage," *Journal of Fashion Marketing and Management,* vol. 18, pp. 20-35, 2014.
[117] IMD. (2018, March 3). *World Competitiveness Yearbook 2018 (International Institute for Management Development (IMD) ed.)*. Available: https://www.imd.org/research-knowledge/books/world-competitiveness-yearbook-2018/
[118] T. I. Chacko, J. G. Wacker, and M. M. Asar, "Technological and human resource management practices in addressing perceived competitiveness in agribusiness firms," *Agribusiness,* vol. 13, pp. 93-105, 1997.
[119] D. Cetindamar and H. Kilitcioglu, "Measuring the competitiveness of a firm for an award system," *Competitiveness Review: An International Business Journal,* vol. 23, pp. 7-22, 2013.
[120] M. N. Akroush, "Organizational capabilities and new product performance: The role of new product competitive advantage," *Competitiveness Review: An International Business Journal,* vol. 22, pp. 343-365, 2012.
[121] M. E. Porter, "The microeconomics of development," in *Paper for the Competitiveness and Development Vision and Priorities for Action Conference*, 2001.
[122] M. Porter, "Clusters, innovation, and competitiveness: New findings and implications for policy," in *Presentation given at the European Presidency Conference on Innovation and Clusters in Stockholm*, 2008.
[123] IPS. (2011, April 3rd). *IPS National Competitiveness Research (Institute of Industrial Policy Studies (IPS) ed.)*. Available: http://csm.ips.or.kr/english/research/develop_05.aspx
[124] Y.-L. Lai, M.-S. Hsu, F.-J. Lin, Y.-M. Chen, and Y.-H. Lin, "The effects of industry cluster knowledge management on innovation performance," *Journal of Business Research,* vol. 67, pp. 734-739, 2014.
[125] S. Li, B. Ragu-Nathan, T. Ragu-Nathan, and S. S. Rao, "The impact of supply chain management practices on competitive advantage and organizational performance," *Omega,* vol. 34, pp. 107-124, 2006.
[126] A. A. Thatte, "Competitive advantage of a firm through supply chain responsiveness and SCM practices," University of Toledo, 2007.
[127] A. Waheeduzzaman, "Competitiveness and convergence in G7 and emerging markets," *Competitiveness Review: An International Business Journal,* vol. 21, pp. 110-128, 2011.
[128] G. Adams, B. Gangnes, and Y. Shachmurove, "Why is China so competitive? Measuring and explaining China's competitiveness," *The World Economy,* vol. 29, pp. 95-122, 2006.

[129] J. Bonales-Valencia, A. I. Zamora-Torres, and C. F. Ortiz-Paniagua, "Variables e Índices de Competitividad de las Empresas Exportadoras, utilizando el PLS," *Cimexus,* vol. 10, pp. 13-32, 2017.
[130] J. Fagerberg, M. Srholec, and M. Knell, "The competitiveness of nations," presented at the DRUID Tenth Anniversary Summer Conference, Aalborg, Denmark, 2005.
[131] S. Amin and A. Hagen, "Strengthening American international competitiveness: A recommended strategy," *American Business Review,* vol. 16, p. 94, 1998.
[132] M. M. Soto, "System dynamics in the simulation of the effect of knowledge management on the supply chain of corn agroindustry (Zea mays L.)," *Revista Técnica de la Facultad de Ingeniería Universidad del Zulia,* vol. 36, 2013.
[133] A. Attia and I. Essam Eldin, "Organizational learning, knowledge management capability and supply chain management practices in the Saudi food industry," *Journal of Knowledge Management,* 2018.
[134] R. Kant and M. Singh, "An integrative framework of knowledge management enabled supply chain management," in *2008 IEEE International Conference on Industrial Engineering and Engineering Management*, 2008, pp. 53-57.
[135] H.-C. Moon and D.-S. Cho, "National competitiveness: A nine factor approach and its empirical application," *Journal of International Business and Economy, Fall,* pp. 17-38, 2000.
[136] V. E. Hoffmann, G. S. C. Lopes, and J. J. Medeiros, "Knowledge transfer among the small businesses of a Brazilian cluster," *Journal of Business Research,* vol. 67, pp. 856-864, 2014.
[137] C. T. Horngren, G. Foster, and S. M. Datar, *Contabilidad de costos un enfoque gerencial*: Pearson educación, 2007.
[138] Z. Bodie and R. C. Merton, *Finanzas*: Pearson Educación, 2004.
[139] J. Medrano Leal, "Plan de modernización tecnológica de la ganadería bovina colombiana," 2002.
[140] L. Agüero Cobo, "Estrategia de fidelización de clientes," 2014.
[141] C. A. López Suárez and C. A. Pinilla Quintero, "Diseño e implementación de un sistema computacional de peticiones, quejas y reclamos," Universidad Libre de Pereira, 2012.
[142] Y. Ccollana Salazar, "Rotación del personal, absentismo laboral y productividad de los trabajadores," 2015.
[143] A. Siliceo, *Capacitación y desarrollo de personal*: Editorial Limusa, 2006.
[144] M. Fernández, G. Millán, M. Calvetty Ramos, M. Basso, and M. C. Mouteira, "Efectos sobre el suelo de efluentes de producción porcina intensiva," in *XIX Jornadas de Divulgación Técnico-Científicas, VI Jornada Latinoamericana, IV Jornadas de Ciencia y Tecnología y III Reunión Transdisciplinaria en Ciencias Agropecuarias (Facultad de Ciencias Veterinarias y Facultad de Ciencias Agrarias, Universidad Nacional de Rosario)(Casilda y Zavalla, 16 y 17 de agosto de 2018)*, 2018.

[145] A. Quitio and J. Carlos, "Plan de manejo ambiental para la Unidad de Investigación Porcina Experimental Tunshi," Escuela Superior Politécnica de Chimborazo, 2018.
[146] B. Sauza-Ávila, D. C. Ramírez, S. S. P. Castañeda, C. B. Lechuga-Canto, and A. H. Cervantes-Monsrea, "Biodigestores anaerobios para la reducción de contaminantes ganaderos una estrategia fiscal en las empresas porcinas," *Ingenio y Conciencia Boletín Científico de la Escuela Superior de Cd. Sahagún,* vol. 5, 2018.
[147] A. Pacco, R. Vela, R. Miglio, L. Quipuzco, J. Juscamaita, C. Álvarez*, et al.*, "Propuesta de parámetros de diseño de un reactor UASB para el tratamiento de aguas residuales porcinas," *Scientia agropecuaria,* vol. 9, pp. 381-391, 2018.
[148] S. Chiva Vicent, J. G. Berlanga Clavijo, R. Martínez Cuenca, and J. Climent Agustina, "Depuración de aguas residuales: digestión anaerobia," 2018.
[149] M. Medina, "Reciclaje de desechos sólidos en América Latina," *Frontera Norte,* vol. 11, pp. 1-25, 1999.
[150] P. G. R. Colombia, "Pacto Global Red Colombia," ed: Obtenido de https://www. pactoglobal-colombia. org, 2018.
[151] R. S. Kaplan and D. P. Norton, "Balanced scorecard," in *Das Summa Summarum des Management*, ed: Springer, 2007, pp. 137-148.
[152] F. Machlup, *The production and distribution of knowledge in the United States* vol. 278: Princeton university press, 1962.
[153] D. Bell, "The coming of the post-industrial society," in *The Educational Forum*, 1973, pp. 574-579.
[154] P. Drucker, *The age of discontinuity: Guidelines to our changing society*: Routledge, 2017.
[155] I. Nonaka, "A dynamic theory of organizational knowledge creation," *Organization science,* vol. 5, pp. 14-37, 1994.
[156] R. M. Grant, "Toward a knowledge-based theory of the firm," *Strategic management journal,* vol. 17, pp. 109-122, 1996.
[157] I. Nonaka and H. Takeuchi, *The knowledge-creating company: How Japanese companies create the dynamics of innovation*: Oxford university press, 1995.
[158] T. H. Davenport and L. Prusak, *Working knowledge: How organizations manage what they know*: Harvard Business Press, 1998.
[159] H. G. C. Castillo, "El modelo de la triple hélice como un medio para la vinculación entre la universidad y empresa," *Revista Nacional de administración,* vol. 1, pp. 85-94, 2010.
[160] Á. L. Arboníes and S. Azúa, *Cómo evitar la miopía en la gestión del conocimiento*: Díaz de Santos, 2001.
[161] A. Marshall, "Principles of economics," *London: Macmillan,* 1920.
[162] D. Weiss and T. Minshall, "Negative effects of relative proximity and absolute geography on open innovation practices in high-tech SMEs in the UK," in *Management of Innovation and Technology (ICMIT), 2014 IEEE International Conference on*, 2014, pp. 1-6.

[163] A. B. Cyrino, R. Parente, D. Dunlap, and B. B. de Góes, "A critical assessment of Brazilian manufacturing competitiveness in foreign markets," *Competitiveness Review: An International Business Journal,* vol. 27, pp. 253-274, 2017.
[164] M. Porter, "The competitive advantage of nations," ed: Free Press, New York, 1990.
[165] R. Boschma, "Proximity and innovation: a critical assessment," *Regional studies,* vol. 39, pp. 61-74, 2005.
[166] I. Nonaka and H. Takeuchi, "The knowledge-creating company: How Japanese companies create the dynamics of innovation," *Long range planning,* vol. 4, p. 592, 1996.
[167] R. McAdam and S. McCreedy, "A critical review of knowledge management models," *The learning organization,* vol. 6, pp. 91-101, 1999.
[168] M. Boisot, *Information and organizations: The manager as anthropologist*: Fontana London, 1987.
[169] F. Nickols, "KM overview," *URL: http://home. att. net/~ discon/KM/KM_Overview_Context. htm(accessed: 18.10. 2015),* 2000.
[170] K. Wigg, "Knowledge management foundations," *Knowledge management foundations,* 1993.
[171] M. W. McElroy, "The new knowledge management: complexity," *Learning, and Sustainable,* 2003.
[172] H. Rollett, *Knowledge management: Processes and technologies*: Springer Science & Business Media, 2012.
[173] W. R. Bukowitz and R. L. Williams, *The knowledge management fieldbook*: Financial Times/Prentice Hall, 2000.
[174] M. H. Zack, "Managing codified knowledge," *Sloan management review,* vol. 40, pp. 45-58, 1999.
[175] I. Nonaka, *The knowledge-creating company*: Harvard Business Review Press, 2008.
[176] G. Hedlund, "A model of knowledge management and the N-form corporation," *Strategic management journal,* vol. 15, pp. 73-90, 1994.
[177] H. McLaughlin and R. Thorpe, "Action Learning-A Paradigm in Emergence: the Problems Facing a Challenge to Traditional Management Education and Development," *British Journal of Management,* vol. 4, pp. 19-27, 1993.
[178] K. Wiig, "Knowledge Management Foundations: thinking about-how people and organizations create, represent, and use knowledge," *Arlington, Texas: Schema,* 1993.
[179] Y. Li, Y. Liu, and H. Liu, "Co-opetition, distributor's entrepreneurial orientation and manufacturer's knowledge acquisition: Evidence from China," *Journal of Operations Management,* vol. 29, pp. 128-142, 2011.
[180] E. Mazzola and G. Perrone, "A strategic needs perspective on operations outsourcing and other inter-firm relationships," *International Journal of Production Economics,* vol. 144, pp. 256-267, 2013.

[181] A. Y.-L. Chong and R. Bai, "Predicting open IOS adoption in SMEs: An integrated SEM-neural network approach," *Expert Systems with Applications,* vol. 41, pp. 221-229, 2014.
[182] Y.-H. Chen, T.-P. Lin, and D. C. Yen, "How to facilitate inter-organizational knowledge sharing: The impact of trust," *Information & Management,* vol. 51, pp. 568-578, 2014.
[183] A. C. G. Maçada, J. C. Costa, M. Oliveira, and C. Curado, "Information management and knowledge sharing in supply chains operating in Brazil," *International Journal of Automotive Technology and Management,* vol. 13, pp. 18-35, 2013.
[184] T. Machikita and Y. Ueki, "Knowledge transfer channels to Vietnam for process improvement," *Management Decision,* vol. 51, pp. 954-972, 2013.
[185] G. Briscoe, A. R. Dainty, and S. Millett, "Construction supply chain partnerships: skills, knowledge and attitudinal requirements," *European Journal of Purchasing & Supply Management,* vol. 7, pp. 243-255, 2001.
[186] T. Y. Choi, J. Budny, and N. Wank, "Intellectual property management: A knowledge supply chain perspective," *Business Horizons,* vol. 47, pp. 37-44, 2004.
[187] A. H. Lee, H. H. Chen, and S. Chen, "Suitable organization forms for knowledge management to attain sustainable competitive advantage in the renewable energy industry," *Energy,* vol. 89, pp. 1057-1064, 2015.
[188] B. van Hoof, "Organizational learning in cleaner production among Mexican supply networks," *Journal of Cleaner Production,* vol. 64, pp. 115-124, 2014.
[189] S. Schrettle, A. Hinz, M. Scherrer-Rathje, and T. Friedli, "Turning sustainability into action: Explaining firms' sustainability efforts and their impact on firm performance," *International Journal of Production Economics,* vol. 147, pp. 73-84, 2014.
[190] M. K. Lim, M.-L. Tseng, K. H. Tan, and T. D. Bui, "Knowledge management in sustainable supply chain management: Improving performance through an interpretive structural modelling approach," *Journal of cleaner production,* vol. 162, pp. 806-816, 2017.
[191] N. Y. Patil and R. M. Warkhedkar, "Knowledge management implementation in Indian automobile ancillary industries: An interpretive structural model for productivity," *Journal of Modelling in Management,* vol. 11, pp. 802-810, 2016.
[192] S. K. Patil and R. Kant, "A hybrid approach based on fuzzy DEMATEL and FMCDM to predict success of knowledge management adoption in supply chain," *Applied Soft Computing,* vol. 18, pp. 126-135, 2014.
[193] M. F. Acar, M. Tarim, H. Zaim, S. Zaim, and D. Delen, "Knowledge management and ERP: Complementary or contradictory?," *International Journal of Information Management,* vol. 37, pp. 703-712, 2017.
[194] Z. Irani, A. Sharif, M. M. Kamal, and P. E. Love, "Visualising a knowledge mapping of information systems investment evaluation," *Expert Systems with Applications,* vol. 41, pp. 105-125, 2014.

[195] M. M. Bagheri, "Investigate the Effect of Information Systems on Supply Chains with Mediation of Knowledge Management in Iran Khodro Company," *International Business Management,* vol. 10, pp. 4153-4162, 2016.
[196] J. Trujillo-Diaz, F. N. Diaz-Piraquive, M. M. Herrera, and J. Gomez, "Modeling the Colombian Swine Supply Chain from a Knowledge Management Perspective," in *Communications in Computer and Information Science*. vol. 1027, C. Springer, Ed., ed Springer Nature Switzerland AG 2019: Springer, Cham, 2019, pp. 25-35.
[197] D. J. Kurtz, E. J. Soriano Sierra, and G. Varvakis, "Fluxo de conhecimento interorganizacional: estudo de múltiplos casos em uma cadeia produtiva," *Espacios,* vol. 34, p. 9, 2013.
[198] G. Selva, "Analysis of the Competitiveness of the Pork Industry in Denmark," in *99th seminar of the EAAE - The Future of Rural Europe in the Global Agri-Food System",* , Copenhagen, Denmark, 2005, pp. 24-27.
[199] A. Báez Hernández, C. A. Hernández Medina, J. M. Perdomo Vázquez, R. Garcés González, and M. Alibet Carrasco, "Modelo de gestión del conocimiento para el desarrollo agropecuario local," *Estudios sociales (Hermosillo, Son.),* vol. 28, pp. 0-0, 2018.
[200] R. A. Rincón, "Gestión del conocimiento y aprendizaje organizacional: una visión integral," *Informes Psicológicos,* vol. 17, pp. 53-70, 2017.
[201] 3tres3. (May 15th). *Economia - Precios del cerdo (3tres3 - Comunidad Profesional Porcina ed.)*. Available: https://www.3tres3.com/cotizaciones-de-porcino/
[202] PorkColombia. (2018, August 28). *Boletín - Ronda de precios # 34 (PorkColombia ed.)*. Available: https://www.miporkcolombia.co/wp-content/uploads/2018/08/Semana34de2018.pdf
[203] J. Supo, "Cómo validar un instrumento: La guía para validar un instrumento en 10 pasos," *Lima, Lima, Perú,* 2013.
[204] J. Escobar-Pérez and Á. Cuervo-Martínez, "Validez de contenido y juicio de expertos: una aproximación a su utilización," *Avances en medición,* vol. 6, pp. 27-36, 2008.
[205] P. R. Garrote and M. del Carmen Rojas, "La validación por juicio de expertos: dos investigaciones cualitativas en Lingüística aplicada," *Revista Nebrija de lingüística aplicada a la enseñanza de lenguas,* pp. 124-139, 2015.
[206] H. C. Oviedo and A. C. Arias, "Aproximación al uso del coeficiente alfa de Cronbach," *Revista colombiana de psiquiatría,* vol. 34, pp. 572-580, 2005.
[207] S. A. Domínguez-Lara and C. Merino-Soto, "¿ Por qué es importante reportar los intervalos de confianza del coeficiente alfa de Cronbach?," *RLCSNJ,* vol. 13, 2015.
[208] R. A. Hernández-Nieto, "Contributions to statistical analysis," *Mérida: Universidad de Los Andes,* vol. 193, 2002.
[209] S. Ihobe, "Guía de indicadores medioambientales para la empresa," *Ingeniería Química,* vol. 32, pp. 227-234, 2000.

[210] Á. Salazar, "Diseño de Indicadores Ambientales para la Evaluación y Seguimiento de Planes de Manejo Ambiental de Producción de Agroquímicos," ed: Bogotá: Universidad de la Salle. Facultad de Ingeniería Ambiental y Sanitaria, 2006.
[211] B. Marr, G. Schiuma, and A. Neely, "Intellectual capital–defining key performance indicators for organizational knowledge assets," *Business Process Management Journal,* vol. 10, pp. 551-569, 2004.
[212] L. A. Galicia Alarcón, J. A. Balderrama Trápaga, and R. Edel Navarro, "Validez de contenido por juicio de expertos: propuesta de una herramienta virtual," *Apertura (Guadalajara, Jal.),* vol. 9, pp. 42-53, 2017.